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A MANUAL FOR THE IDENTIFICATION BY EPIDERMAL CHARACTERISTICS OF 75 FORAGE PLANT SPECIES OF THE SOUTHERN INTERIOR OF BRITISH COLUMBIA

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ABSTRACT

A dichotomous key and photomicrographs of plant species common to the southern interior of British Columbia are presented as a tool for herbivore diet determination. For most taxa, photographs representing both sides of the leaf surface, stem and, in some instances, flowers are shown. All botanical specimens were photographed at 100X magnification.

Keywords:

British Columbia, epidermal patterns, fecal analysis, microhistology, plant key.

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INTRODUCTION

Beginning with Dusi (1949), the use of microhistological examination of feces has gained wide recognition as a viable method to determine herbivore diets. Over the past three decades, the list of animal species for which this technique has been employed continues to grow and includes: cattle (Hubbard and Hansen 1976; Vavra et al. 1977; Vavra et al. 1978), horses (Hansen 1976; Olson and Hansen 1977; Hansen et al. 1977), burros (Hansen and Martin 1973), domestic sheep (Olson and Hansen 1977), white-tailed deer (Quinton et al. 1979), mule deer (Hansen and Dearden 1975; Hansen and Reid 1975; Pulliam 1978), reindeer (Dearden et al. 1975), bighorn sheep (Todd 1972; Todd and Hansen 1973; Wilson 1976; Wikeem and Pitt 1979), beaver (Voth and Black 1973), rabbits (Flinders and Hansen 1975), opossum (Fitzgerald and Waddington 1979), and black-tailed prairie dogs (Hansen and Gold 1977) among others, as well as many African and Australian species.

Despite its widespread use, however, the validity of microhistological analysis of feces, as a quantitative method to determine animal diet, remains unresolved. Studies comparing known plant species mixes to diet estimates based upon fecal analysis have concluded both that significant digestibility differences do occur among plant species (Pulliam 1978), and that animal diet composition can be determined within acceptable limits (Sparks and Malechek 1968; Todd and Hansen 1973; Dearden 1974; Johnson and Pearson 1981). Little doubt remains, however, that most plant species ingested by herbivores can be accurately identified by trained observers (Ward 1970; Johnson and Pearson 1981) and that useful qualitative data can be derived.

Much of the popularity of this technique undoubtedly rests on the practical aspects of sampling animal populations in a nondestructive manner. However, fundamental to implementing fecal analysis for diet determination are reference keys and photomicrographs of forage plant species likely to be encountered by the study herbivore. Unfortunately, few such keys are currently available for diet analysis research.

The key and photomicrographs presented here represent a collection of taxa common to the interior grasslands of southern British Columbia. Many species in the key are widely distributed in the lower third of the province and often occur in forested portions of the Ponderosa Pine-Bunchgrass zone as well as drier portions of the Interior Douglas fir zone (Krajina 1965). However, caution should be exercised for determining diets of animal species whose home ranges encompass a broader variety of habitat types than those mentioned above. Supplemental photomicrographs will be essential in such cases.

For most plant species, several photographs are presented representing the leaf adaxial (upper) and abaxial (lower) surfaces, the stem, and, in some cases, flowers. All photomicrographs were photographed at 100X magnification. Beginning on page 39, photomicrographs are presented alphabetically within the following plant groups: grasses and sedges, forbs, trees and shrubs. Appendices I through III designate the epidermal surface, photomicrographs number, and page number location(s) of each plant species occurring within the key.

The dichotomous key follows the format of Korphage (1974). Dichotomous divisions are based on characteristics observable in the accompanying photomicrographs and may not represent absolute features of every plant species. Similarly, some variations in epidermal characteristics might be expected within a plant species over geographic ranges and throughout the phenological development of the plant. However, gross characteristics should be consistent enough within a plant species to differentiate taxa adequately.

The key and photomicrographs are complementary and careful study of both are recommended before diet analyses are undertaken. Clearly, familiarity with the epidermal characteristics of the reference plant species expected in the animal's diet will lead to efficient and accurate determination of the botanical components in the fecal output. Common epidermal features of a grass leaf and trichomes of dicotyledons are illustrated in Figures 1 and 2.

Users should note that trichomes often may not accompany epidermal fragments in the feces. Holes in the epidermal surfaces generally indicate the removal of trichomes during digestion. Plant fragments which do not key readily without trichomes should be keyed again assuming trichomes are present. Users should note any detached trichomes and record their presence while sampling. Similarly, stomata may be absent on epidermal fragments found in the feces, especially for species which normally have few stomata present. Again, these species should be keyed as far as possible assuming stomata are present while referring to the reference photographs. Fragments may key to more than one group.

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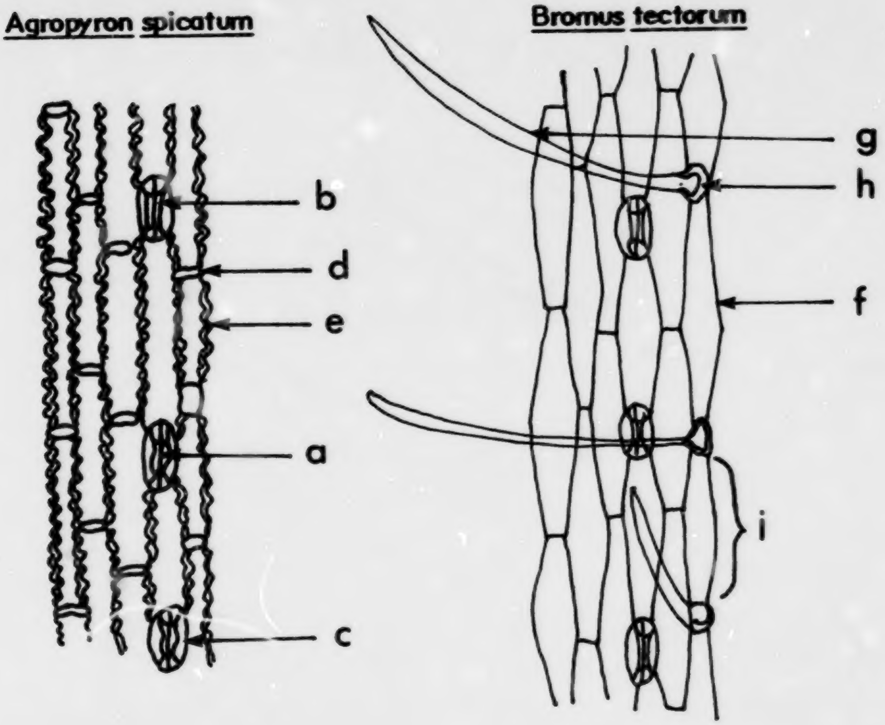

Agropyron spicatum

Bromus tectorum

Poa secunda

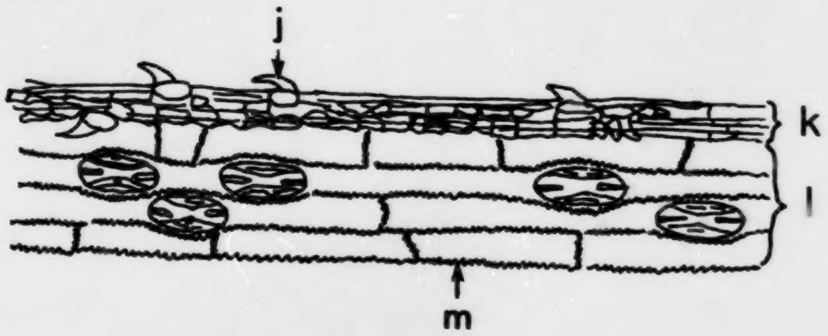

Figure 1 - Epidermal features of grass leaf

a - stomata;
b - guard cell;
c - subsidiary cell;
d - cork cell;
e - undulating cell wall (thick, double wall image);
f - smooth cell wall;
g - trichome (macrohair);
h - trichome base;
i - tapered cell;
j - prickle hair;
k - vein;
l - intervein;
m - thin, undulating, rope-like cell wall.

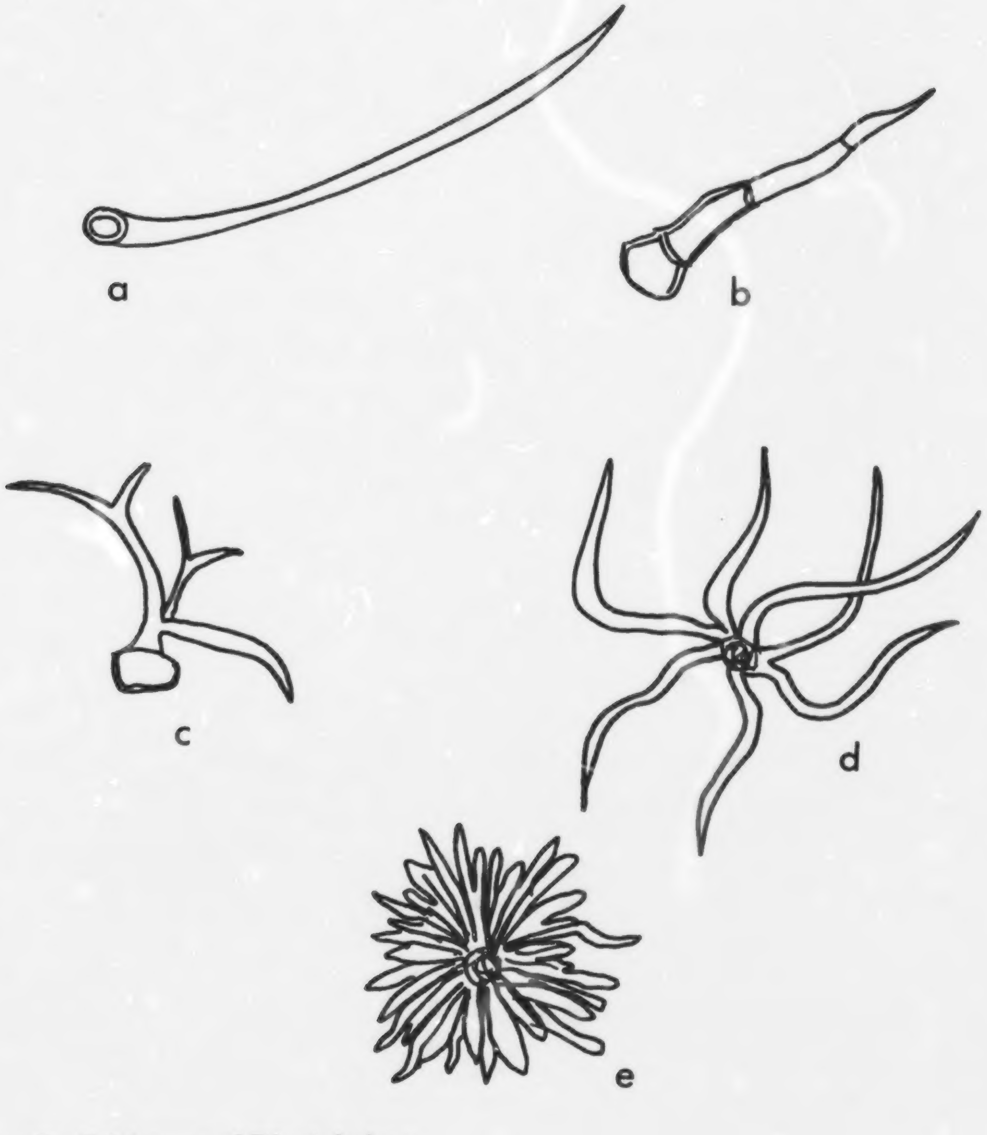

Figure 2 - Trichomes of Dicotyledons

a - single celled;
b - multicellular;
c - branched;
d - stellate;
e - peltate.

GLOSSARY

Angular	Cell walls possessing well-defined angles or sharp corners.
Cleft	Cell walls indented to mid-point of cell or slightly more.
Crenate	Cell walls having margins with rounded notches projecting at right angles to the cell wall edge.
Cork cells	One of two kinds of short cells found in grass species. Cell walls typically resemble cork with cell cavity empty.
Elliptical	In the form of an ellipse; approximately one and one half times as long as wide.
Elongate	Cells prolonged in length or width.
Guard cells	Specialized epidermal cells surrounding stomata.
Incised	Cut deeply into sharp lobes. Cells resemble pieces of jigsaw puzzle.
Intervein	The region of the epidermis between veins.
Linear	Arranged in lines or nearly so.
Lobed	Cell walls deeply indented but less than half way to the cell center.
Macrohairs	Appendages to the epidermis appearing as hairs. Generally one-celled with a thick cell wall and much larger than microhairs. Vary in size, shape, and cell wall thickness.
Microhairs	Appendages to the epidermis appearing as small hairs. Generally two-celled, very small, and extremely thin walled. Much smaller than macrohairs.
Nodules	Cell walls projecting and terminating in a small swelling.
Ovate	Egg-shaped in outline with a broader end at the base.
Peltate	Shield or target-shaped, attached from underside.
Prickle-hair	Appendages to the epidermis. Stout, thick-walled, sharply pointed cells with swollen bases. Generally single-celled. Also called asperities.
Stellate	Star-shaped, branched appendages radiating from a single point.
Silica bodies	Small deposits within the inner cell cavity of grass silica cells. May appear round, elongated, notched, or saddle-shaped.

Silica cells	One of two kinds of short cells found in the epidermis of grass species. May occur in rows, pairs, or alone. The inner cavity of each cell filled with a single silica-body.
Stomata	Specialized cells of the epidermis permitting gas exchange between leaf cells and the surrounding atmosphere.
Subsidiary cells	Two or more cells immediately adjacent to guard cells surrounding the stomata; includes prickle-hairs, macrohairs, and microhairs.
Trichomes	A slender projection of the epidermis with cells arranged end-to-end; includes prickle-hairs, macrohairs, and microhairs.
Undulate	Cell margins irregular, gently winding in and out.

DICHOTOMOUS KEY FOR EPIDERMAL FRAGMENTS

- A. Cells and stomata arranged in linear order; elongated and rectangular
  - B. Cells usually more than four times longer than wide
    - C. Cells usually interspersed with cork cells and/or silica cells — Group I; page 8
    - CC. Cells not interspersed with cork cells or silica cells — Group II; page 14
  - BB. Cells usually less than four times as long as wide, often appearing square in vein region; cells not interspersed with cork or silica cells — Group III; page 15
- AA. Cells and stomata not in linear order; usually not elongated and rectangular
  - B. Cells conspicuously longer than broad; cell walls may be undulating or smooth — Group IV; page 16
  - BB. Cells not conspicuously longer than broad
    - C. Cells square to ovate — Group V; page 23
    - CC. Cells not square to ovate
      - D. Cells incised, as in jigsaw puzzle — Group VI; page 29
      - DD. Cells not incised; irregularly shaped; cell walls may or may not undulate; stomata often very numerous and often interrupting continuous cell walls — Group VII; page 31

GROUP I

1a Cell walls smooth

  2a Cell walls tapering at ends; width of cell conspicuously narrower at the end than the middle of the cell

    3a Trichomes mostly macrohairs; microhairs may also be present

      4a Trichomes both macrohairs and microhairs; cells commonly shorter than trichomes; stomata common, arranged in rows between veins — Bromus tectorum[a] (12)[b]

      4b Trichomes macrohairs only; cells often as long or longer than trichomes; stomata common, arranged in rows between veins — Bromus mollis (9)

    3b Trichomes mostly prickle-hairs, macrohairs may also be present

      4a Prickle-hairs occurring both interveinally and over veins

        5a Prickle-hairs common, occurring at almost all junctions between cells; length of prickle-hairs in intervein region mostly equal to stomatal length — Koeleria cristata (25)

        5b Prickle-hairs not common, primarily occurring over veins; length of prickle-hairs in intervein region mostly less than stomatal length — Bromus inermis (8)

      4b Prickle-hairs occurring only over veins

        5a Stomata common between veins

          6a Cork cells common; stomata mostly distinctly elliptical — Poa pratensis (28)

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[a] Nomenclature follows Hitchcock and Cronquist (1978).

[b] Indicates photomicrograph number, beginning on page 39.

6b Cork cells rare or absent; stomata elliptical but tending toward roundish — *Dactylis glomerata* (16, 17)

5b Stomata not common between veins; stomata nearly round; cells elongated, length greater than 20X stomatal length — *Bromus inermis* (7)

2b Cell walls not conspicuously tapered at end

3a Trichomes macrohairs; microhairs may also be present

4a Cells commonly longer than trichomes; trichomes common both interveinally and over veins; stomata common, arranged in single rows between veins — *Bromus tectorum* (13)

4b Cells commonly shorter than trichomes; trichomes generally restricted to veins; stomata common, arranged in one or two rows between veins; microhairs may be present. — *Bromus mollis* (10)

3b Trichomes prickle-hairs; prickle-hairs common, occurring both interveinally and over veins; stomata common, arranged in two or three rows between veins — *Koeleria cristata* (25)

1b Cell walls undulating or rope like

2a Stomata absent in intervein region

3a Macrohairs present between veins but not abundant; prickle-hairs present both interveinally and over veins; silica cells abundant; cell walls slightly undulating, thin — *Stipa occidentalis* (32)

3b Macrohairs not present between veins; prickle-hairs common

4a Prickle-hairs absent interveinally; cells thick-walled; silica cells present — *Festuca idahoensis* (18)

4b Prickle-hairs common both interveinally and over veins; cork cells abundant, most often adjacent to prickle-hair; cell wall thin — *Festuca scabrella* (21)

2b Stomata present in intervein region

3a Stomata mostly occurring in single rows

4a Trichomes present

5a Trichomes prickle-hairs only

6a Prickle-hairs found both interveinally and over veins, prickle-hair length usually less than stomatal length; stomata rare to common, roundish — *Stipa comata* (35)

6b Stomata elongated — *Koeleria cristata* (24)

5b Trichomes macrohairs only

6a Cell wall undulation conspicuous; stomata only slightly ovate; silica and cork cells present — *Stipa occidentalis* (33)

6b Cell wall undulations not conspicuous but present; stomata clearly elongated; trichomes present at junction of almost all cells; cork and silica cells not present — *Agropyron spicatum* (2)

4b Trichomes absent

5a Cell walls thick, undulations conspicuous, cells mostly rectangular rarely tapering at ends; cork cells abundant, separating almost all cells — *Agropyron spicatum* (1)

5b Cell walls thin, undulations less conspicuous than above, sometimes cell walls appear smooth; cells often wider in middle than ends although not greatly so; cork cells common but not separating most cells — *Poa pratensis* (27)

3b	Stomata occurring in two or more companion rows	
4a	Trichomes absent	
5a	Cell walls thin, stomata mostly elliptical and widely spaced, usually 2 or more stomatal lengths apart, undulations conspicuous	Koeleria cristata (26)
5b	Cell walls thick	
6a	Cell wall undulations mostly rope-like or inconspicuous	
7a	Stomata rounded or nearly so, well spaced; cells elongated and slightly tapering at ends	Bromus tectorum (14)
7b	Cell walls thick, rope-like appearance, undulations not apparent; stomata widely spaced, usually greater than 3 stomatal lengths apart	Agropyron spicatum (3)
6b	Cell wall undulations conspicuously wavelike	
7a	Undulations widely spaced, deep and rounded; cells elongated, usually greater than 5X stomatal length; stomata elliptical and widely spaced, usually greater than 4 stomatal lengths apart	Apera interrupta (6)
7b	Undulations not widely spaced, rounded; cells usually less than 5X stomatal length; stomata nearly rounded to slightly elliptical, often spaced less than 4 stomatal lengths apart	Poa sandbergii (31)
4b	Trichomes present	
5a	Trichomes macrohairs	

6a Trichomes abundant occurring at junction of nearly all cells; silica and cork cells not present, stomata not common — *Festuca scabrella* (22)

6b Trichomes not abundant but common; cork cells present; stomata common, elliptical — *Bromus mollis* (11)

5b Trichomes prickle-hairs

6a Prickle-hairs not occurring interveinally; confined to region above vein

7a Prickle-hairs short, less than stomatal length

8a Silica cells sparse, cells often nearly rectangular, short cells and cork cells rare, stomata elliptical — *Poa sandbergii* (29)

8b Silica cells common

9a Cell walls undulating, conspicuously wavelike; stomata elliptical — *Apera interrupta* (4)

9b Cell walls undulating but ropelike; stomata squarish to rectangular in appearance — *Festuca idahoensis* (19)

7b Prickle-hairs long, greater than stomatal length; cells often slightly wider in the middle than at ends; cell lengths generally greater than 5X stomatal length except cells in rows immediately adjacent to stomatal rows; silica cells not present — *Apera interrupta* (5)

6b Prickle-hairs occurring interveinally and over veins

7a Cell walls thick

8a Prickle-hairs abundant

9a Base of veinal prickle-hairs generally longer than stomatal length; interveinal prickle-hairs approximately equal to stomatal length — *Festuca scabrella* (23)

9b Base of prickle-hairs conspicuously shorter than stomatal length both interveinally and over veins

10a Cell wall undulations conspicuously wavelike; stomata often separated by less than 5 stomatal lengths — Festuca idahoensis (20)

10b Cell wall undulations mostly ropelike or inconspicuous; stomata mostly separated by more than 5 stomatal lengths — Agropyron spicatum (3)

8b Prickle-hairs not abundant, hair length nearly as long as stomatal length — Stipa occidentalis (34)

7b Cell walls thin

8a Prickle-hairs long, often as long as stomatal length or nearly so; large prickle-hairs common over veins; stomata elongated — Poa sandbergii (30)

8b Prickle-hairs short, usually shorter than stomatal length

9a Prickle-hairs present but not abundant over veins

10a Prickle-hairs abundant interveinally — Koeleria cristata (24)

10b Prickle-hairs not abundant interveinally — Apera interrupta (4)

9b Prickle-hairs abundant both interveinally and over veins; stomata rounded or nearly so, often less than 2 stomatal lengths apart — Stipa comata (36)

GROUP II

1a Cell walls smooth

  2a Stomata present

    3a Stomata linearly arranged in two bands separated by a stomata free region of cells; stomata plus subsidiary cells appearing somewhat rectangular with rounded corners; cell shape irregularly rectangular with angles often different than 90 degrees — *Pseudotsuga menziesii* (175)

    3b Stomata linearly arranged but homogeneously occurring over the epidermal surface; stomata plus subsidiary cells nearly round to slightly elliptical; cell shape mostly rectangular — *Calochortus macrocarpus* (57)

  2b Stomata absent; cells appearing double-walled, one end squared, the other angular — *Pseudotsuga menziesii* (174)

1b Cell walls undulating or ropelike

  2a Trichomes present as short prickle-hairs arranged in rows adjacent to evenly spaced rows of stomata, surrounded by 4 to 6 subsidiary cells — *Pinus ponderosa* (169,170)

  2b Trichomes absent; cell walls crenately undulating; stomata surrounded by 2 subsidiary cells, closely spaced, nearly round — *Carex petasata* (15)

GROUP III

1a	Stomata absent; cell walls thick, undulating slightly	*Smilacina racemosa* (130)
1b	Stomata present	
2a	Cell length generally less than 2X stomatal length; stomata nearly round	*Selaginella wallacei* (122)
2b	Cell length generally greater than 2x stomatal length; stomata mostly oval	*Zygadenus venenosus* (135, 136)

GROUP IV

1a Cell walls crenate

    2a Undulations appearing bead-like, forming large nodules; base of trichomes, when present, wider than stomatal length *Phlox longifolia* (115, 116)

    2b Undulations not bead-like, forming small nodules; trichomes common, width of trichome base less than stomatal length *Achillea millefolium* (37,38)

1b Cell walls not crenate; smooth or undulating slightly

    2a Cells generally rectangular

        3a Trichomes absent

            4a Stomata absent

                5a Nuclei not present; cell walls thick; cell shape squarish *Smilacina racemosa* (130)

                5b Nuclei present; cells may have double wall image; cells rectangular to ovate *Phlox longifolia* (117)

            4b Stomata present

                5a Stomata common, round; cell walls thin *Berberis aquifolium* (152)

                5b Stomata rare, elliptical; cell walls thin, may have double wall image *Smilacina racemosa* (131)

        3b Trichomes present

            4a Stomata numerous

                5a Stomata linearly arranged; trichomes shorter than cell length, rounded, or if missing, base appears as round cell *Zigadenus venenosus* (135, 136)

                5b Stomata not linearly arranged

6a Trichomes long, greater than 5X cell length, rigid, tapering to a sharp point — *Plantago patagonica* (118, 119, 120)

6b Trichomes short, generally equal to or slightly greater than cell length, tapering slightly to a rounded point — *Silene noctiflora* (125)

4b Stomata few; stomatal length greater than base of trichomes; trichomes long and wavy, appearing flat — *Antennaria parvifolia* (40)

2b Cells irregularly rectangular, angles of many walls conspicuously not 90 degrees

3a Stomata absent

4a Trichomes absent; cells rectangular to ovate, nuclei present — *Phlox longifolia* (117)

4b Trichomes present

5a Trichomes very common and of two types; 2X to 5X cell length, tapering to sharp point; and, often greater than 10X cell length tapering to rounded point; base of trichomes mostly less than cell width — *Purshia tridentata* (176)

5b Trichomes common but not dense, and all of one type; length of trichomes vary but mostly less than 10X cell length; base of trichomes often greater than or equal to cell width — *Lithospermum ruderale* (102)

3b Stomata present

4a Trichomes absent

5a Stomata mostly elliptical

6a Cell length generally greater than 5X stomatal length — *Zigadenus venenosus* (137)

- **6b** Cell length generally less than 5X stomatal length — Microseris troximoides (110)
- **5b** Stomata squarish to roundish
  - **6a** Cell length generally less than 5X stomatal length; stomatal length generally greater than cell width — Berberis aquifolium (152)
  - **6b** Cell length generally greater than 5X stomatal length; stomatal length less than or approximately equal to cell width — Sisymbrium altissimum (128)
- **4b** Trichomes present
  - **5a** Trichomes mostly single-celled
    - **6a** Trichomes conspicuously abundant
      - **7a** Trichomes comprised of both microhairs and macrohairs, or macrohairs only of different sizes
        - **8a** Trichomes consisting of microhairs and macrohairs; stomata elliptical; stomatal length greater than base of macrohairs — Geum triflorum (94)
        - **8b** Trichomes consisting of macrohairs of different sizes
          - **9a** Cell walls angular; macrohairs similar but conspicuously of different length; stomata elliptical, stomatal length greater than cell width — Phacelia hastata (114)
          - **9b** Cell walls rounded; trichomes distinctly of two types; greater than 10X cell length, single-celled; and, less than 10X cell length, multicelled and tapering to a round point — Centaurea diffusa (63)
      - **7b** Trichomes all of similar size

8a Trichomes less than 5X cell length

- **9a** Stomatal length greater than base of trichomes
  - **10a** Stomata linearly arranged or nearly so, common, elliptical; trichomes tapering to a rounded point — *Crepis atrabarba* (72)
  - **10b** Stomata randomly arranged, elliptical; trichomes gradually tapering to a slightly rounded point — *Ribes cereum* (183)
- **9b** Stomatal length less than base of trichome
  - **10a** Stomata abundant, round to slightly elliptical; cell walls more commonly rounded; trichomes slightly tapering to a rounded point — *Lomatium triternatum* (105)
  - **10b** Stomata present but not abundant, elliptical; cell walls more commonly angular; trichomes slightly tapering to a point — *Lupinus sericeus* (108)

8b Trichome length greater than 5X cell length

- **9a** Cells conspicuously elongated
  - **10a** Stomata common, elliptical; stomatal length generally less than length of trichome base; trichomes appearing rounded — *Astragalus purshii* (52)
  - **10b** Stomata rare, rounded to slightly elliptical; stomatal length greater than length of trichome base; trichomes appearing flat — *Eriogonum heracleoides* (159)
- **9b** Cells not conspicuously elongated, stomata not common, elliptical; stomatal length greater than length of trichome base; trichomes appearing flat — *Artemisia frigida* (145, 146)

6b Trichomes not abundant

7a Trichomes branched; stomata common, elliptical; stomatal length less than cell width, cells conspicuously elongated; cell walls commonly rounded at one end and angular at the other — Arabis holboellii (41, 43)

7b Trichomes not branched

8a Cells conspicuously elongated

9a Stomatal length less than length of trichome base — Astragalus miser (49)

9b Stomatal length greater than length of trichome base, trichomes gradually tapering to a rounded point — Chaenactis douglasii (66)

8b Cells not conspicuously elongated

9a Trichome length less than 2X cell length — Symphoricarpos albus (191)

9b Trichome length greater than 2X cell length; trichomes tapering to a rounded point — Chaenactis douglasii (64)

5b Trichomes mostly 2- to multi-celled

6a Trichomes microhairs or macrohairs only

7a Trichome length less than 5X cell length

8a Stomatal length greater than length of trichome base; trichomes 2-celled tapering to a sharp point — Erigeron filifolius (83, 84, 85)

8b Stomatal length less than length of trichome base

9a	Stomata round to slightly elliptical, abundant; base of trichomes raised; cells may have double wall image	Achillea millefolium (39)
9b	Stomata elliptical, common; trichomes terminating in a ball-shaped cell	
10a	Cells conspicuously elongated; trichomes usually shorter than cell length	Dodecatheon cusickii (77)
10b	Cells not conspicuously elongated; trichomes usually longer than cell length	Heuchera cylindrica (97)
7b	Trichome length greater than 5X cell length; trichomes macrohairs only	
8a	Trichomes 2-celled	
9a	Cell walls rounded, may have double wall image, elliptical; cell length usually less than 4X stomatal length	Erigeron filifolius (83)
9b	Cell walls angular; stomata elliptical; cell length usually greater than 4X stomatal length	Antennaria parvifolia (40)
8b	Trichomes multi-celled	
9a	Trichome length generally greater than 20X cell length; base of trichomes thick, tapering to a long, thin, multi-celled structure terminating in a sharp point; cell length in trichomes variable with the first 3 or 4 much shorter than the upper cells	Erigeron pumilus (88)
9b	Trichome length generally less than 20X cell length; trichomes gradually tapering to a sharp point; cell length in trichomes relatively similar; cells may have a double wall image	Gaillardia aristata (91)

6b Trichomes both microhairs and macrohairs

- 7a Macrohairs less than 5X cell length
  - 8a Macrohairs generally multicelled; both macrohairs and microhairs terminating in a sharp point Erigeron corymbosus (82)
  - 8b Macrohairs generally 2-celled; macrohairs terminating in a sharp point; microhairs of two kinds, one terminating in a rounded point and the other capped in a round ball-like cell Castilleja thompsonii (60)
- 7b Macrohairs greater than 5X cell length
  - 8a Trichomes abundant
    - 9a Base of trichomes generally greater than 2X stomatal length Plantago patagonica (118, 119, 120)
    - 9b Base of trichomes generally less than 2X stomatal length, often nearly equal Balsamorhiza sagittata (55)
  - 8b Trichomes not abundant; macrohairs usually 2-celled, tapering to a sharp point; trichome base 2 to 3X stomatal length; microhairs 2-celled, more abundant than macrohairs, length less than 2X cell length; cells may have double wall image Arnica sororia (46)

GROUP V

1a Angles of cell walls rounded, not sharply angled and precise

2a Stomata present

3a Trichomes present

4a Trichomes of two kinds; thin single-celled trichomes greater than 20X stomatal length, appearing flattened, basal width less than stomatal length; and, short, many-celled trichomes, basal width 2X - 3X stomatal length *Centaurea diffusa* (62)

4b Trichomes all similar, single-celled but with two branches; stomata few, subsidiary cells appearing triangular; cell walls mostly undulating *Cornus stolonifera* (156)

3b Trichomes absent

4a Cell walls conspicuously thickened; cells generally ovate; stomata randomly arranged *Penstemon fruticosus* (163)

4b Cell walls slightly thickened; cells generally rectangular; stomata linearly arranged or nearly so *Tragopogon dubius* (134)

2b Stomata absent

3a Cells mostly square, rectangular or irregularly rectangular

4a Trichomes abundant

5a Trichomes multi-celled, greater than 20X cell length, gradually tapering to a sharp point *Balsamorhiza sagittata* (56)

5b	Trichomes single-celled, length less than cell length, diverging from base to a rounded top	*Prunus virginiana* (172)
4b	Trichomes absent or rare	
5a	Most cells nearly square	
6a	Cell walls thin; some cells irregularly and triangularly shaped	*Amelanchier alnifolia* (142)
6b	Cell walls thick; nearly all cells squarish	*Prunus virginiana* (173)
5b	Cells mostly rectangular	
6a	Cell walls undulating; trichomes absent; cell walls thick, often with double wall image	*Epilobium angustifolium* (79)
6b	Cell wall undulation rare or absent	
7a	Cell walls smooth, often with double wall image; cells approximately linearly arranged	*Philadelphus lewisii* (167)
7b	Cell walls rarely undulating; cells randomly arranged	*Amelanchier alnifolia* (141)
3b	Cells mostly ovate	
4a	Nuclei inside cell; cell wall may have double image	*Philadelphus lewisii* (168)
4b	Nuclei not present	
5a	Cell walls thin	*Philadelphus lewisii* (166)
5b	Cell walls thick	
6a	Cell walls undulating slightly	*Symphoricarpos albus* (190)
6b	Cell walls not undulating	

7a	Trichomes present but rare, less than 2X cell length, single-celled, diverging from the base to a rounded top	*Rhus glabra* (179)
7b	Trichomes common and of two types; 5X to 10X cell length, tapering to a sharp point; and, much greater than 10X cell length, tapering to a rounded point	*Purshia tridentata* (177)
1b	Angles of cell walls sharp and precise	
2a	Stomata absent	
3a	Trichomes present but sparse, usually present over veins; cell walls thin with single wall image	*Acer glabrum* (139)
3b	Trichomes absent	
4a	Cells mostly ovate	
5a	Cell walls thick, some appearing with double wall image	*Ceanothus velutinus* (153)
5b	Cell walls thin, not appearing with double wall image	*Philadelphus lewisii* (166)
4b	Cells mostly squarish to rectangular; cell walls thick, most with double wall image	*Arctostaphylos uva-ursi* (144)
2b	Stomata present	
3a	Stomata common to abundant	
4a	Trichomes absent	
5a	Cell walls thin although some may have double wall image	
6a	Inclusions in center of most cells conspicuous; stomata conspicuously elliptical	*Lewisia rediviva* (98, 99)

6b Inclusions in center of cell wall absent; stomata roundish to slightly elliptical — Microseris troximoides (110,111)

5b Cell walls thick, most appearing with double wall image

6a Stomatal length mostly equal to cell length; stomata roundish to slightly elliptical — Ranunculus glaberrimus (121)

6b Stomatal length mostly less than cell length; stomata conspicuously elliptical — Penstemon fruticosus (162)

4b Trichomes present

5a Trichome length less than 10X cell length

6a Trichomes tapering to a rounded point; stomatal length greater than length of trichome base — Penstemon fruticosus (164)

6b Trichomes terminating in a ball-shaped cell; stomatal length less than length of trichome base — Heuchera cylindrica (95, 96)

5b Trichome length greater than 10X cell length

6a Stomatal length conspicuously greater than base of trichome

7a Cell length generally greater than 2X stomatal length; stomata round to slightly ovate; trichomes appear flattened — Eriogonum niveum (160, 161)

7b Cell length generally less than 2X stomatal length; stomata rounded to slightly oval; trichomes appear flattened — Eriogonum heracleoides (157)

6b Stomatal length equal to or less than length of trichome base

- 7a Trichomes of two kinds; long thin trichomes greater than 10X cell length, appearing flat, single-celled; and, short thick trichomes less than 10X cell length, multi-celled; stomata round to slightly ovate — *Centaurea diffusa* (62)
- 7b Trichomes relatively similar
  - 8a Cell walls thick, stomata slightly elliptical; trichomes tapering gradually to a sharp point — *Lithospermum ruderale* (101)
  - 8b Cell walls thin
    - 9a Trichomes abundant, tapering from a thickened base to a slightly rounded point; stomata round or nearly so — *Phacelia hastata* (112, 113)
    - 9b Trichomes very common, gradually tapering to a sharp point; stomata elliptical — *Lupinus sericeus* (106, 107)

3b Stomata present, but rare to sparse

- 4a Trichomes absent — *Rosa nutkana* (185)
- 4b Trichomes present
  - 5a Cell length greater than stomatal length — *Rosa nutkana* (186)
  - 5b Cell length less than stomatal length; stomata surrounded by subsidiary cells

5a Length of trichome base often greater than or equal to cell length; stomata usually contained within cell walls, elliptical; trichomes tapering gradually to a sharp point, appearing flat; cell walls thick, may have double wall image, 4-6-sided Rhus glabra (180)

5b Length of trichome base less than stomatal length; stomata intersecting continuous cell walls, round to slightly elliptical; trichome width relatively uniform terminating in a rounded point, appearing flat; cell walls thick, may have double wall image, usually 5-sided Eriogonum heracleoides (158)

GROUP VI

- 1a Trichomes absent
  - 2a Stomata absent — Berberis aquifolium (151)
  - 2b Stomata present
    - 3a Stomata conspicuously abundant; small nodes apparent throughout cell wall — Epilobium angustifolium (78)
    - 3b Stomata common but not abundant
      - 4a Small nodes apparent throughout cell wall; stomata slightly elliptical to nearly round — Ranunculus glaberrimus (121)
      - 4b Small nodes not apparent throughout cell wall; stomata mostly elliptical — Collinsia parviflora (67)
- 1b Trichomes present
  - 2a Trichomes of two types, more commonly stellate and less often peltate — Shepherdia canadensis (187, 188)
  - 2b Trichomes of one type with a singular projection, may be single- or multi-celled
    - 3a Base of trichomes conspicuously larger than stomatal length
      - 4a Cells appearing with double wall image
        - 5a Base of trichomes circular and flat; trichomes single-celled, pointed, length greater than 4X stomatal length — Lithospermum ruderale (100)
        - 5b Base of trichomes not circular, raised; trichomes single-celled; length less than 4X stomatal length — Silene noctiflora (123)

4b Cells not appearing with double wall image

5a Cells conspicuously large, thick-walled; trichomes short and tapering to a rounded point — *Smilacina racemosa* (129)

5b Cells small, thin-walled; trichomes long

6a Trichomes abundant, single-celled, long and very gradually tapering — *Astragalus purshii* (50, 51)

6b Trichomes evident but not dense, multi-celled, much thicker at base than tip — *Erigeron pumilus* (86, 87)

3b Base of trichomes shorter than or approximately equal to stomatal length

4a Trichomes single-celled

5a Cell walls undulating crenately; stomata common but not abundant

6a Length of trichome base generally greater than stomatal length; stomata mostly roundish to slightly elliptical — *Astragalus purshii* (50)

6b Length of trichome base generally less than stomatal length; stomata distinctly elliptical — *Artemisia frigida* (145)

5b Most cell walls undulating but not crenately; stomata abundant, elliptical and appearing flat at both ends — *Medicago sativa* (109)

4b Trichomes 2- to multi-celled

5a Angles of cell walls rounded, like nodules; trichome length less than 5X width at base, trichomes terminating with a rounded cell — *Dodecatheon cusickii* (75, 76)

5b Angles of cell walls more incised than rounded; trichome length greater than 5X width at base; trichomes terminating with a sharp point — *Balsamorhiza sagittata* (53)

GROUP VII

- 1a Most cell walls undulating
  - 2a Trichomes absent
    - 3a Cells somewhat elongated, commonly longer than wide
      - 4a Stomata absent; cells commonly rectangular but often just so; cells often with double wall image — *Epilobium angustifolium* (79)
      - 4b Stomata present
        - 5a Stomata small; cell length commonly greater than 5X stomatal length — *Arabis holboellii* (42)
        - 5b Stomata large; cell length commonly less than 5X stomatal length
          - 6a Cell walls with small nodes apparent throughout stomata round to slightly elliptical — *Crepis atrabarba* (70)
          - 6b Small nodes absent throughout cell wall; stomata mostly roundish to slightly elliptical; cell length mostly less than 3X stomatal length — *Delphinium bicolor* (74)
    - 3b Cells mostly as long as wide
      - 4a Stomata present
        - 5a Stomata very abundant, nearly round, ends often flat and equal to or greater than cell length — *Berberis aquifolium* (150)
        - 5b Stomata common, mostly elliptical, length mostly less than cell length — *Acer glabrum* (138)

4b Stomata absent; cell with double wall image — *Shepherdia canadensis* (188)

2b Trichomes present

3a Trichomes all of one type

4a Trichomes not abundant

5a Base of trichomes less than or equal to stomatal length

6a Trichomes needle-shaped

7a Trichomes long, greater than 5X cell length — *Symphoricarpos albus* (189)

7b Trichomes short, less than 5X cell length — *Delphinium bicolor* (73)

6b Trichomes stout, wider at middle than either end, less than 5X cell length, mostly located over veins; cell walls undulating slightly, often with small nodes apparent through-out cell walls; stomata often equal to cell length — *Amelanchier alnifolia* (140)

5b Base of trichomes greater than stomatal length

6a Shape of stomata mostly round or nearly so

7a Trichomes branched; length of trichomes generally less than 3X cell length — *Arabis holboellii* (41)

7b Trichomes not branched; length of trichomes generally greater than 3X cell length — *Astragalus miser* (48)

6b Shape of stomata mostly elliptical

7a	Cell walls undulating moderately to deeply cleft	*Sisymbrium altissimum* (127)
7b	Cell walls undulating slightly, may have double wall image	*Astragalus miser* (47)
4b	Trichomes common to abundant	
5a	Stomatal length greater than length of trichome base	
6a	Cell walls undulating moderately into smooth rounded curves; trichomes abundant, appearing flat and transparent	*Artemisia tridentata* (147, 148, 149)
6b	Cell walls undulating slightly, curves irregular often near pointed; small nodes apparent throughout cell wall; trichome size variable, needle-like, appearing rounded	*Geum triflorum* (92)
5b	Stomatal length less than length of trichome base	
6a	Cell walls smooth or undulating only slightly	
7a	Trichomes 2- to multi-celled, gradually tapering from a broad base to a sharp point	*Erigeron corymbosus* (80, 81)
7b	Trichomes single-celled	
8a	Trichomes greater than 5X cell length, needle-like; cell walls thin, undulating slightly, small nodes apparent throughout cell wall	*Geum triflorum* (93)
8b	Trichomes less than 5X cell length, gradually tapering to a rounded point; cell walls thick, often with double wall image	*Silene noctiflora* (124)

6b Cell walls undulating moderately; trichomes 2- to multi-celled, usually greater than 5X cell length, tapering to a sharp point; cells may have double wall image or be interspersed with small nodes throughout — *Arnica sororia* (44, 45)

3b Trichomes of two types

4a Trichomes single-celled; one type with length less than or equal to cell length, tapering rapidly to a rounded point; and the other type with length greater than 3X cell length, tapering to a sharp point; cell walls undulating slightly — *Chaenactis douglasii* (65)

4b Trichomes 2- to multi-celled, one type with length greater than cell length, terminating with a rounded cell; length of other trichome type variable, often greater than 5X cell length, tapering to a sharp point; cell walls undulating moderately — *Castilleja thompsonii* (58, 59)

1b Most cell walls smooth

2a Trichomes absent

3a Stomata not interrupting continuous cell walls — *Comandra umbellata* (68, 69)

3b Stomata interrupting continuous cell walls

4a Length of most cells greater than 2X stomatal length

5a Cells often with double wall image; stomata ovate to roundish — *Crepis atrabarba* (71)

5b Cells not appearing as double wall image; mostly elliptical — *Tragopogon dubius* (132, 133, 134)

4b Length of most cells less than 2X stomatal length

5a Angles of cell walls mostly rounded

6a Stomata distinctly elliptical and generally less than cell length

Prunus virginiana (171)

6b Stomata round to slightly elliptical and often nearly equal to cell length

Philadelphus lewisii (165)

5b Angles of cell walls mostly sharp and precise

6a Cell length mostly greater than stomatal length; stomata mostly elliptical

Philadelphus lewisii (165)

6b Cell length mostly less than or equal to stomatal length

7a Stomatal length mostly equal to cell length

Rosa nutkana (184)

7b Stomatal length almost always greater than cell length

Arctostaphylos uva-ursi (143)

2b Trichomes present

3a Trichome length distinctly greater than 15X cell length

4a Trichomes all similar and single-celled

5a Stomata very numerous; cell length mostly less than 2X stomatal length; cell walls thick, often with double image

Chrysothamnus nauseosus (154, 155)

5b Stomata present but not abundant; cell length mostly greater than 2X stomatal length; cell walls thin

Eriogonum niveum (160, 161)

4b Trichomes generally multi-celled, or may be single-celled if two types of trichomes present

5a Trichomes of 2 types; single-celled greater than 15X cell length, and multi-celled less than 15X cell length
Centaurea diffusa
(62)

5b Trichomes of one type, multi-celled, tapering to a sharp point
Balsamorhiza sagittata
(54)

3b Trichome length distinctly less than 15X cell length

4a Angles of cell walls mostly sharp and precise

5a Trichomes multi-celled

6a Cells often with double wall image, stomata numerous, elliptical; trichomes tapering to a slightly rounded point
Gaillardia aristata
(89,90)

6b Cells mostly not with double wall image

7a Base of trichomes mostly less than 3X stomatal length

8a Base of trichomes conspicuously greater than stomatal length; trichomes gradually tapering to a slightly rounded point
Gaillardia aristata
(89)

8b Base of trichomes approximately equal to or slightly larger than stomatal length; trichomes tapering to a sharp point
Erigeron corymbosus
(80, 81)

7b Base of trichomes mostly greater than 3X stomatal length; trichomes rapidly tapering to a rounded point
Centaurea diffusa
(61, 62)

- 5b Trichomes single-celled
  - 6a Stomata mostly roundish
    - 7a Trichomes abundant, gradually tapering to a sharp point — *Ribes cereum* (181)
    - 7b Trichomes conspicuous but not abundant
      - 8a Trichome length mostly less than 2X cell length — *Lomatium triternatum* (103, 104)
      - 8b Trichome length mostly greater than 2X cell length; trichomes often terminating with a round cell — *Heuchera cylindrica* (96, 97)
  - 6b Stomata mostly elliptical
    - 7a Trichomes generally greater than 2X cell length, tapering to a sharp point — *Ribes cereum* (182)
    - 7b Trichomes generally less than 2X cell length, tapering to a rounded point — *Lomatium triternatum* (103)

4b Angles of cell walls rounded, not sharp and precise

- 5a Trichomes single-celled
  - 6a Length of trichome greater than 5X cell length; some cell walls undulating widely
    - 7a Trichome base less than stomatal length; trichomes abundant, appearing flat and transparent — *Artemisia tridentata* (147, 148, 149)
    - 7b Trichome base greater than stomatal length; trichomes wide at base, tapering to a sharp point — *Sisymbrium altissimum* (126)
  - 6b Length of trichomes less than 5X cell length
    - 7a Trichomes tapering rapidly to a point — *Lomatium triternatum* (104)

7b Trichomes diverging from the base to a rounded, swollen tip *Rhus glabra* (178)

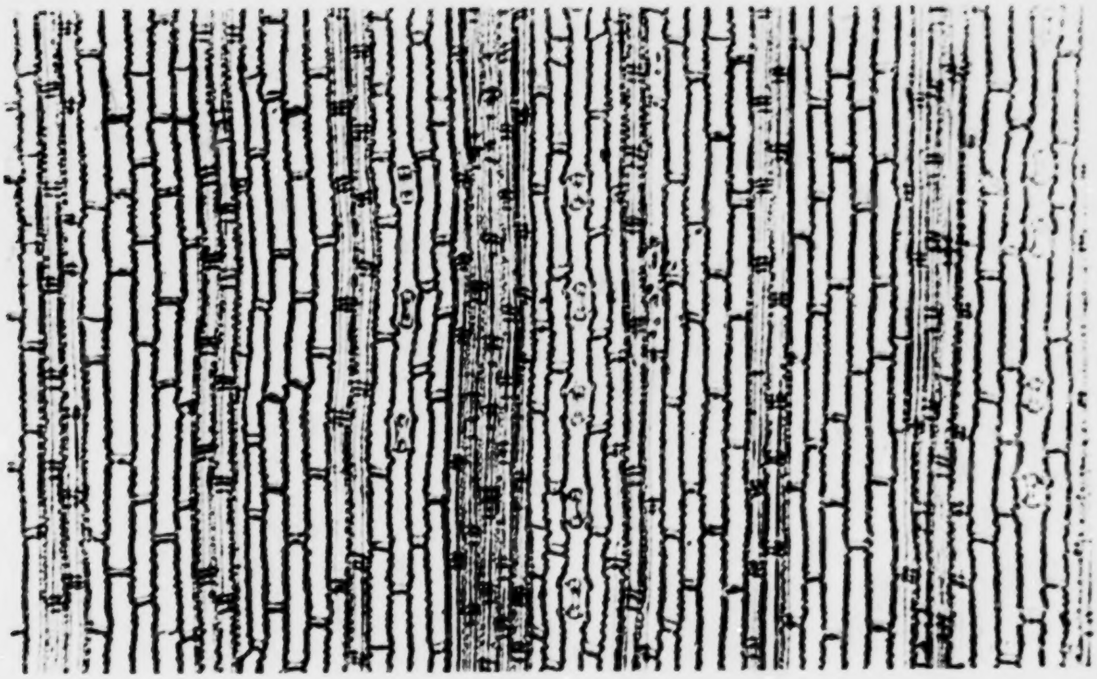
5b Trichomes multi-celled

6a Base of trichomes generally greater than 4X stomatal length; trichomes tapering to a rounded point *Centaurea diffusa* (61)

6b Base of trichomes generally less than 2X stomatal length; trichomes gradually tapering to a sharp point *Erigeron corymbosus* (81)

MICROPICTOGRAPHS

(Numbers 1-191 Indicated In Parentheses)



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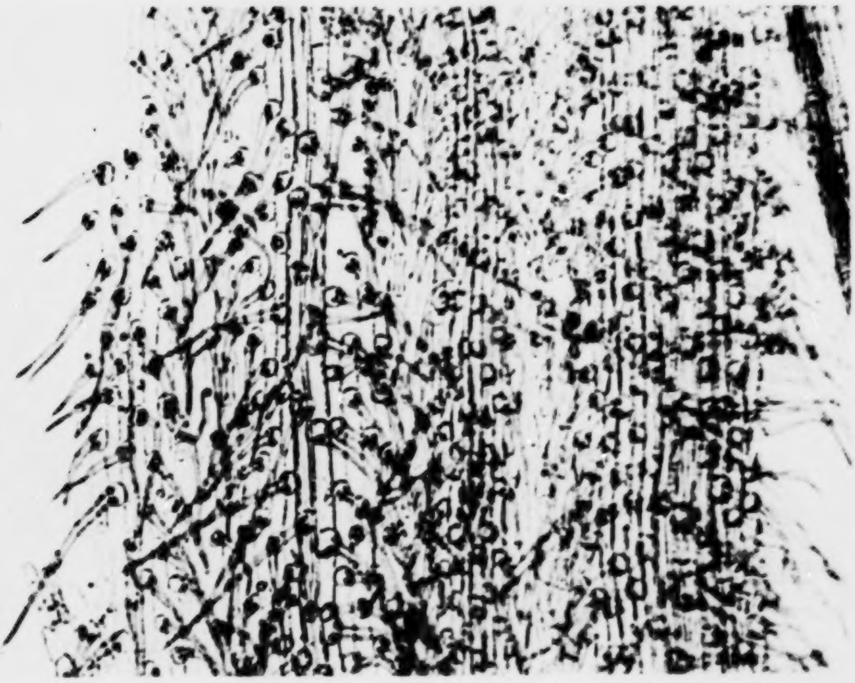

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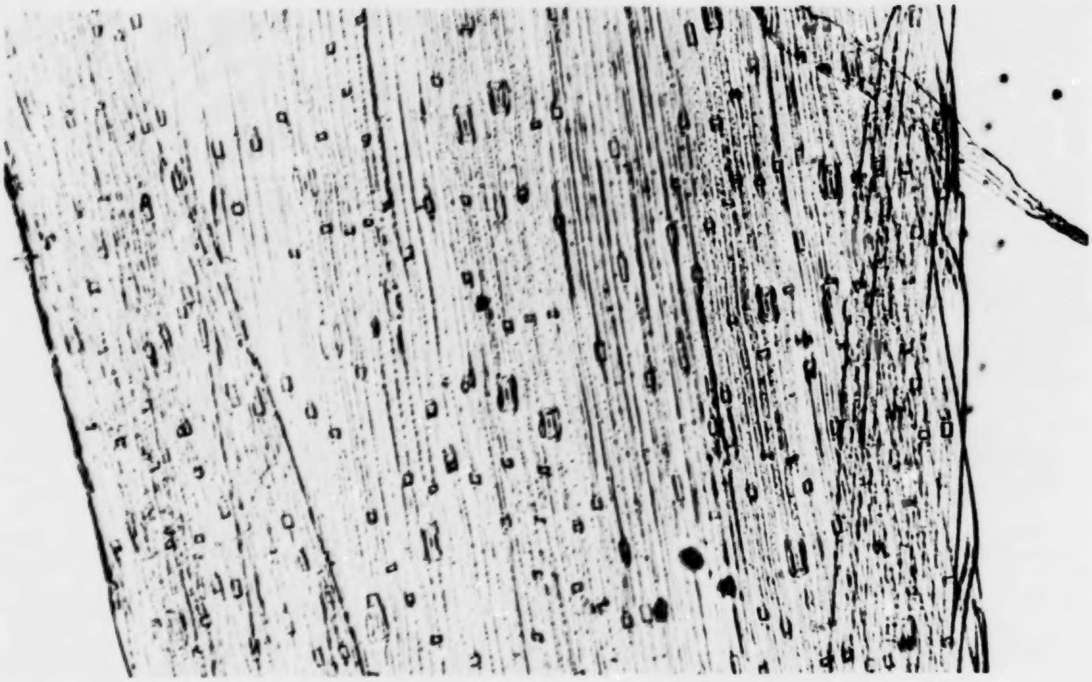

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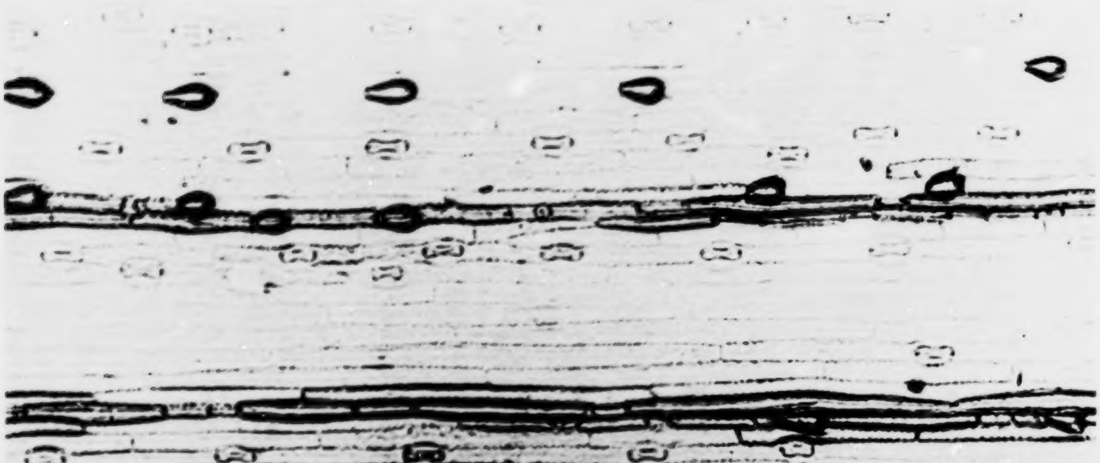

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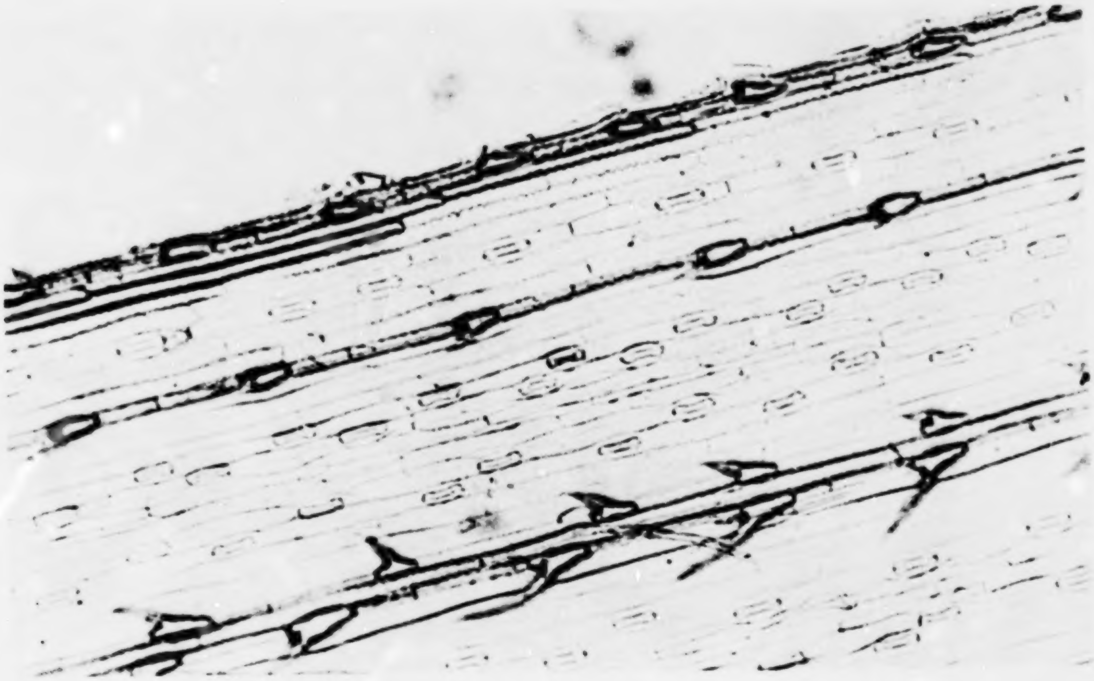

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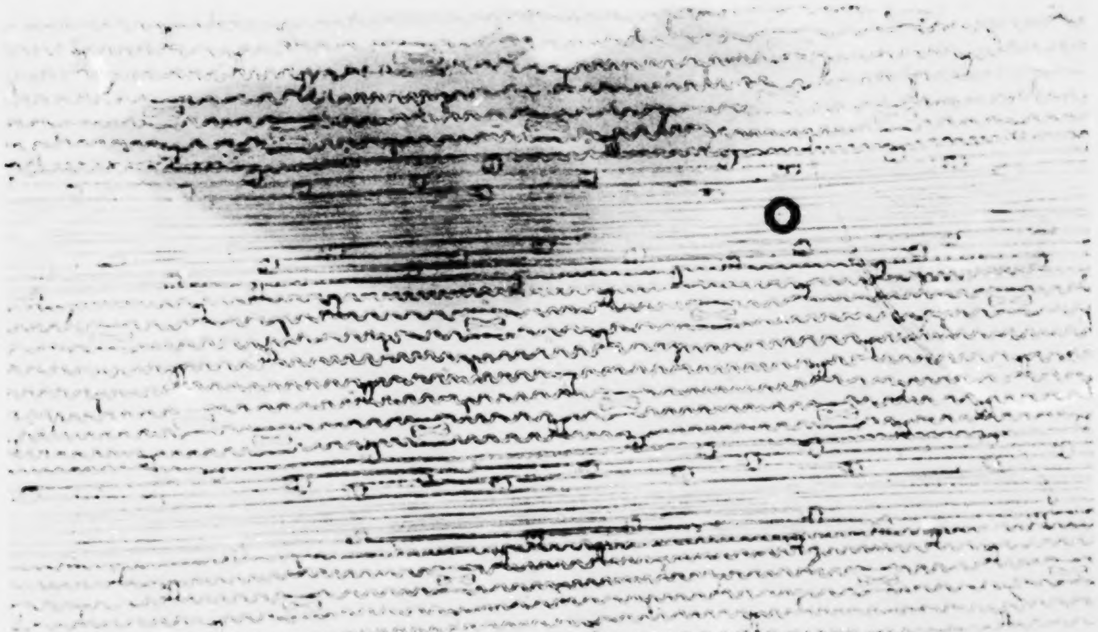

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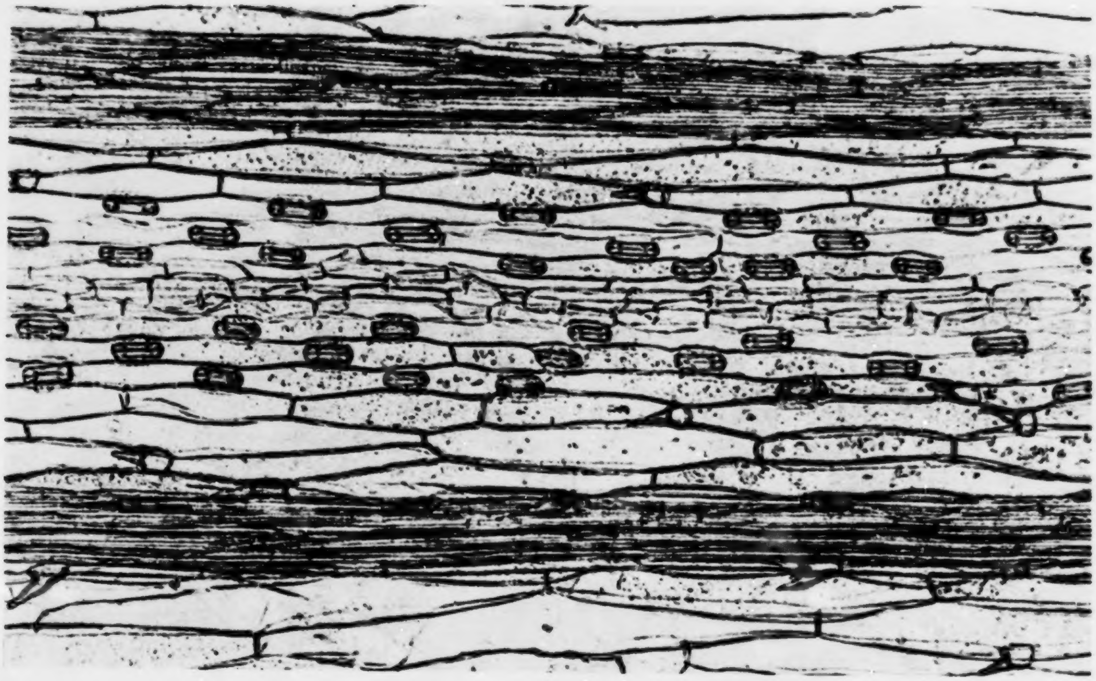

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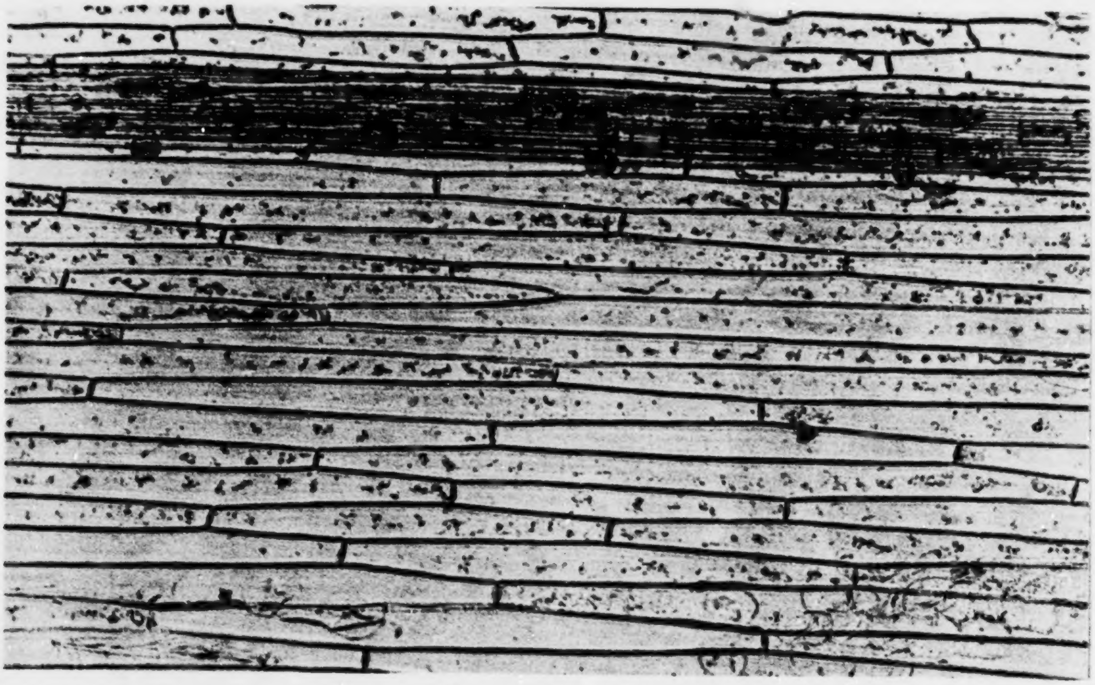

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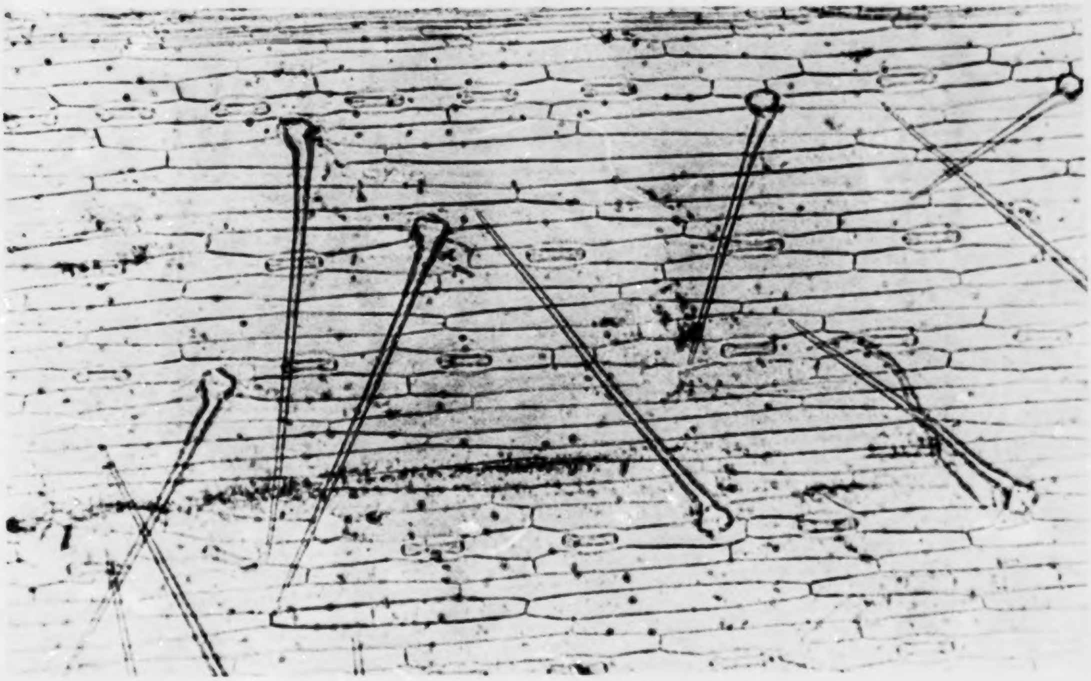

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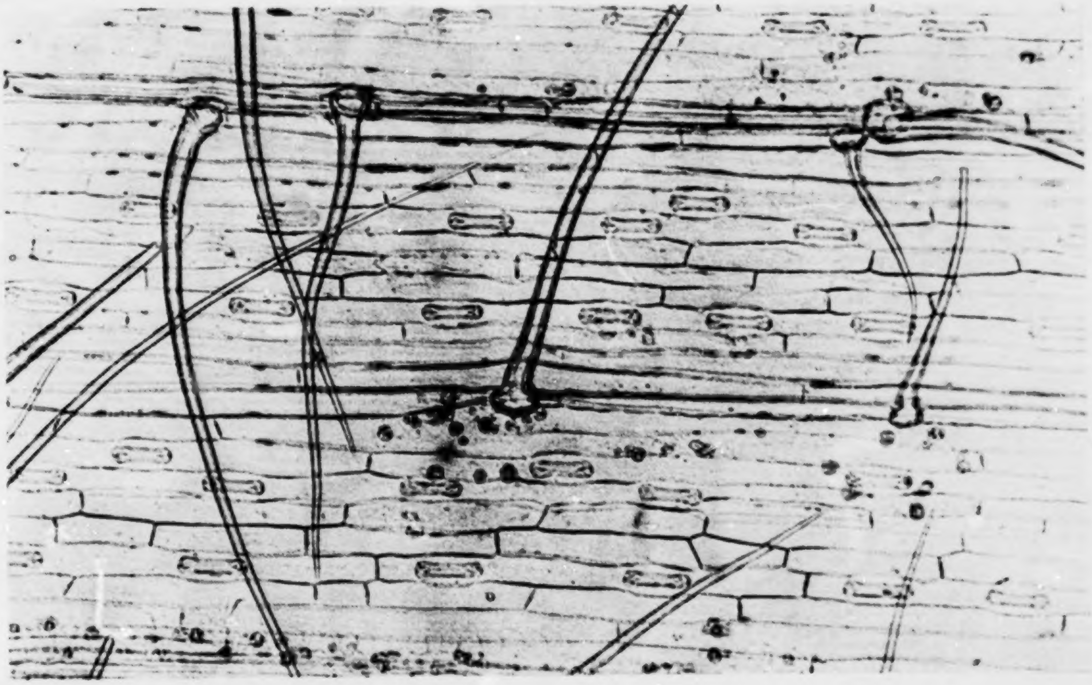
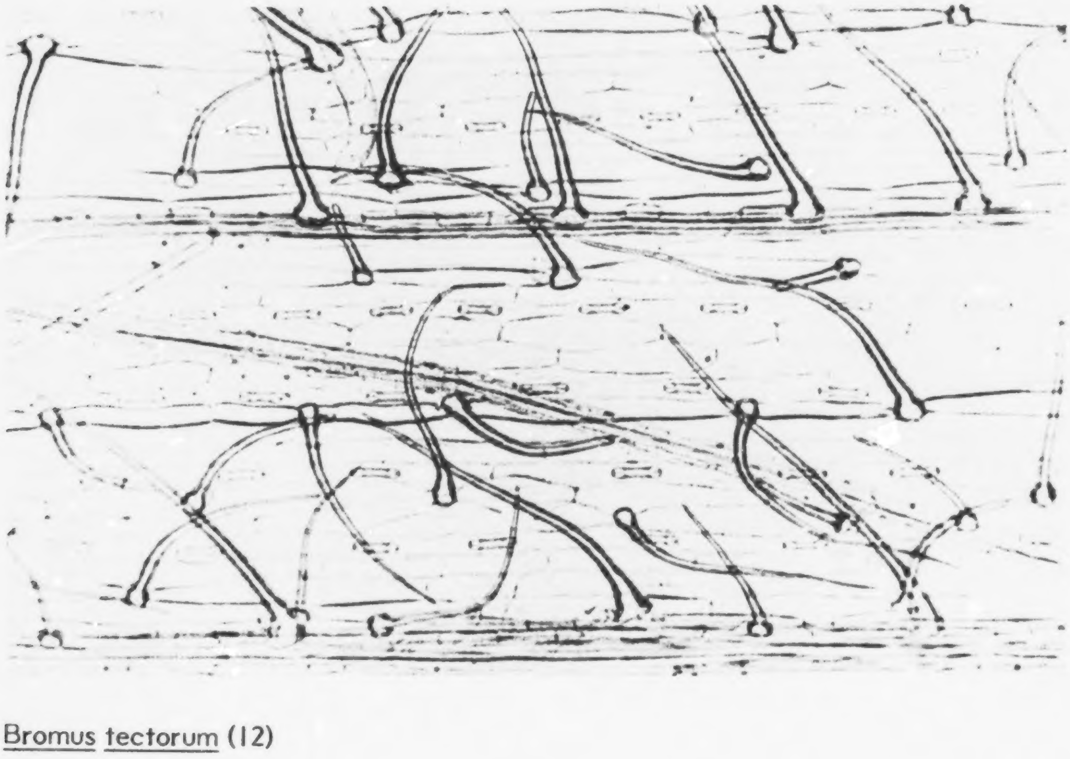


Bromus mollis (10)

Bromus mollis (11)



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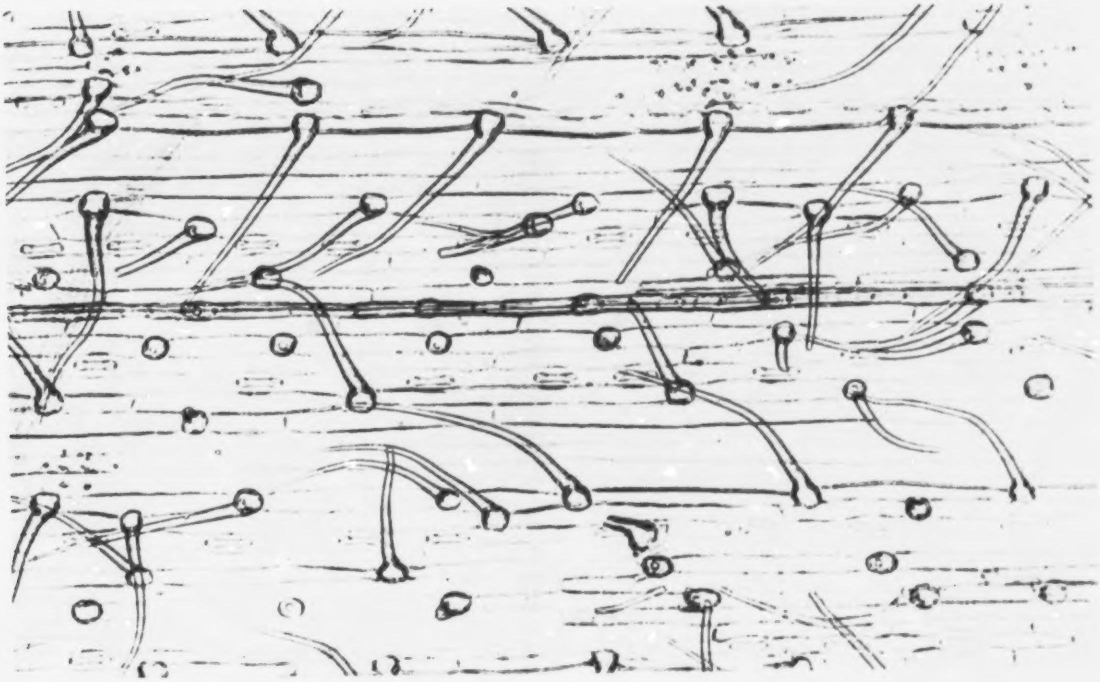

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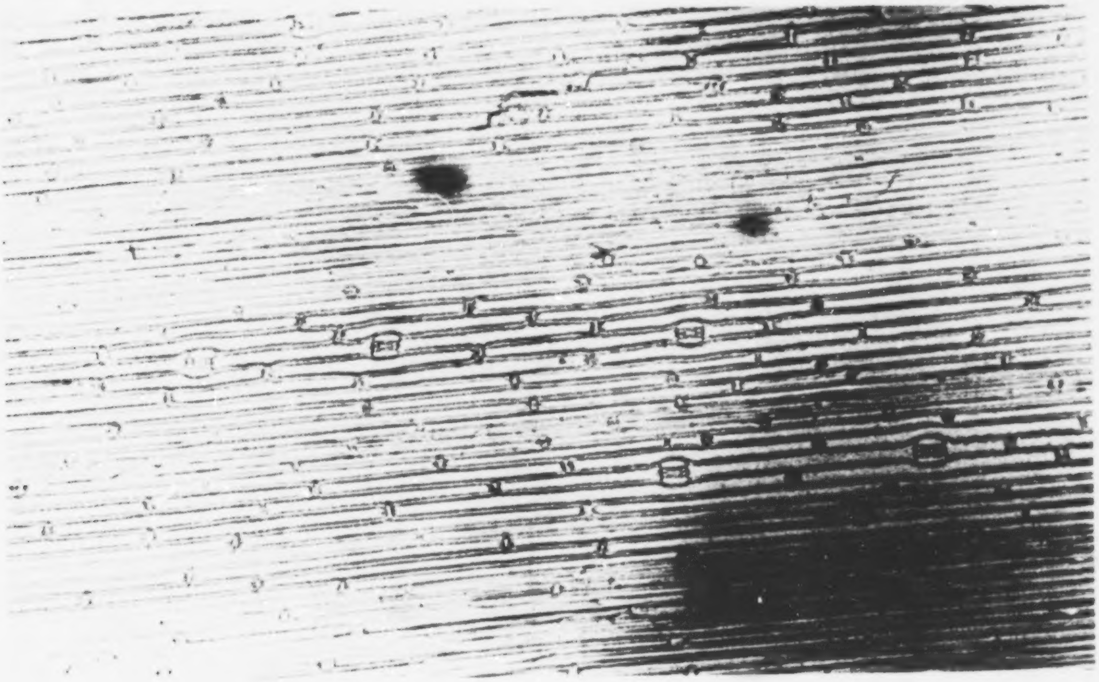

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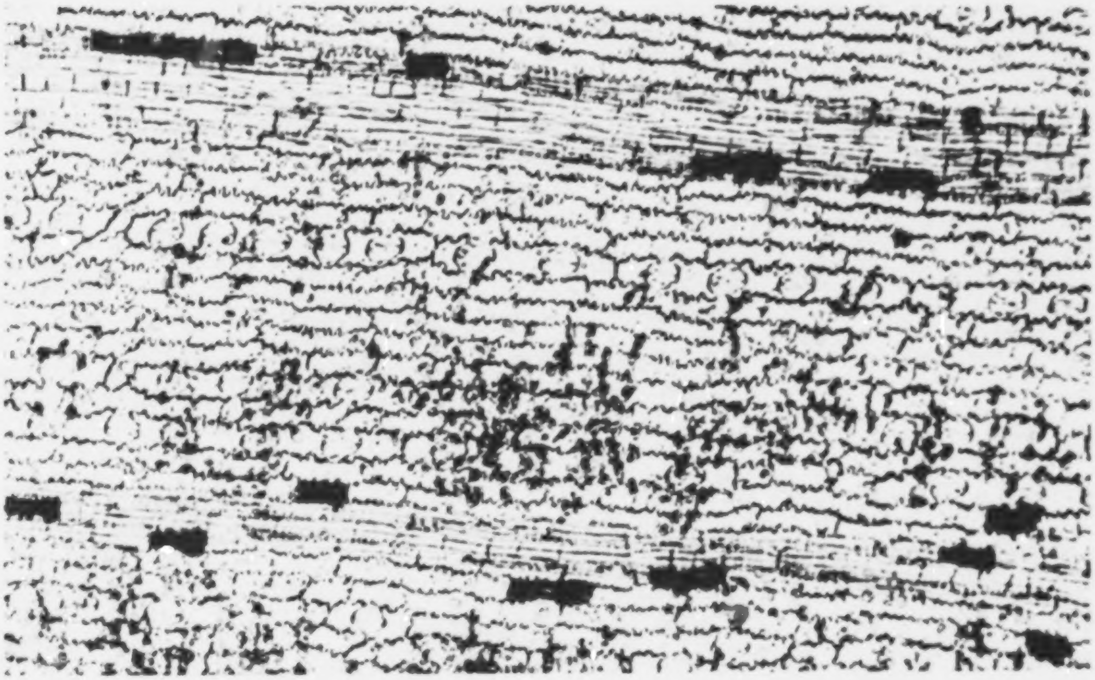

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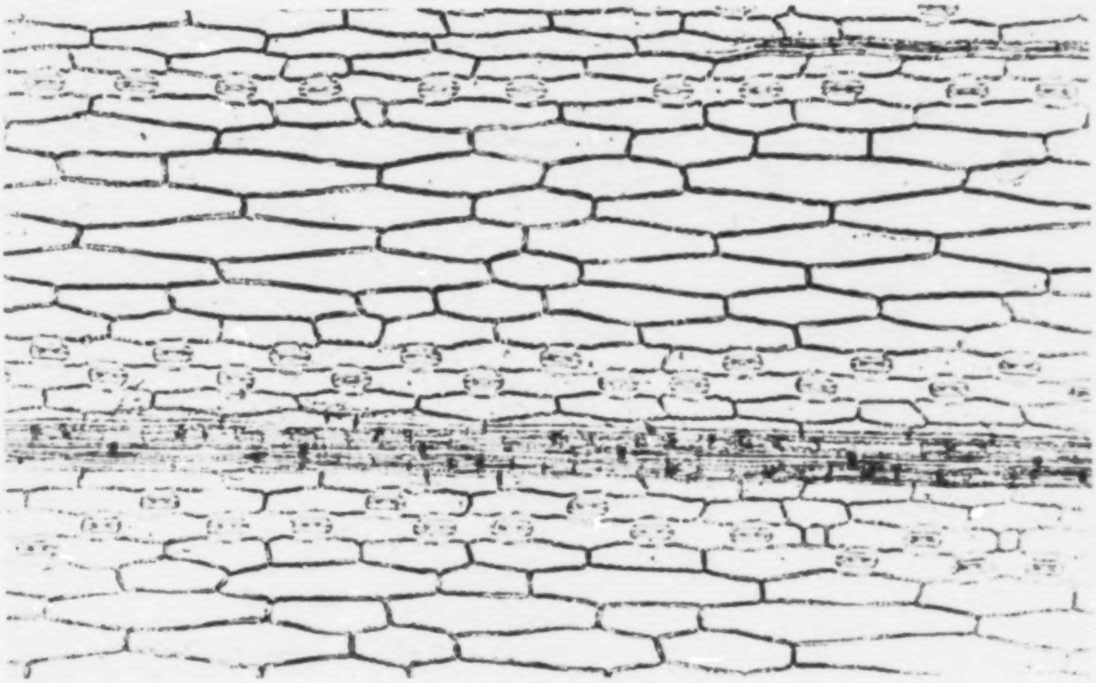
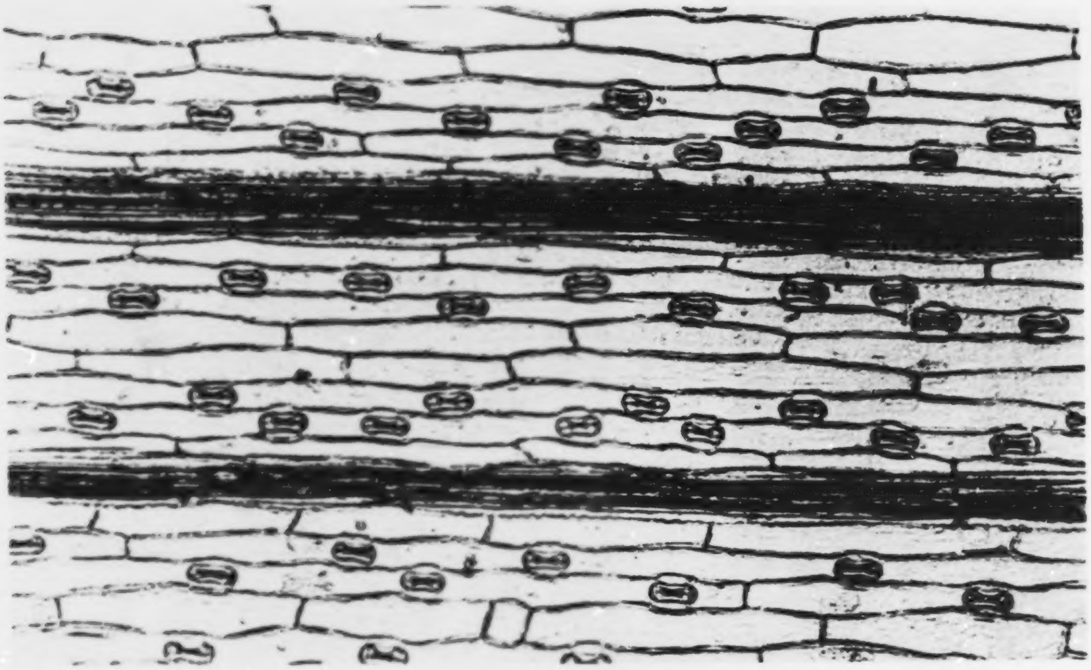


Dactylis glomerata (16)



Dactylis glomerata (17)

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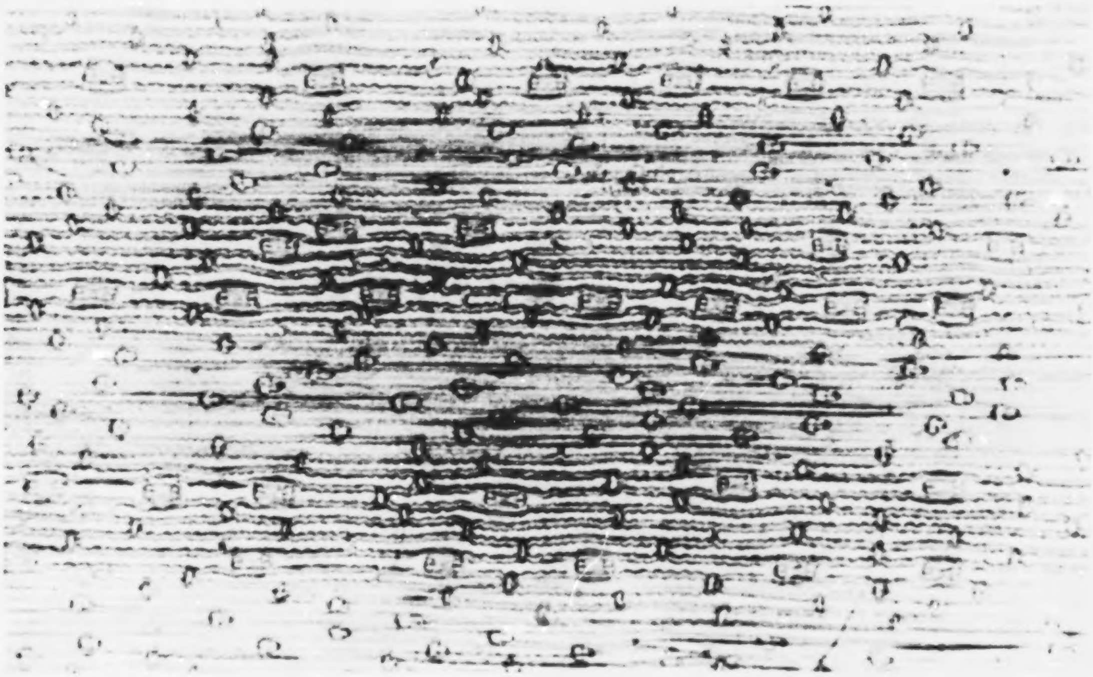

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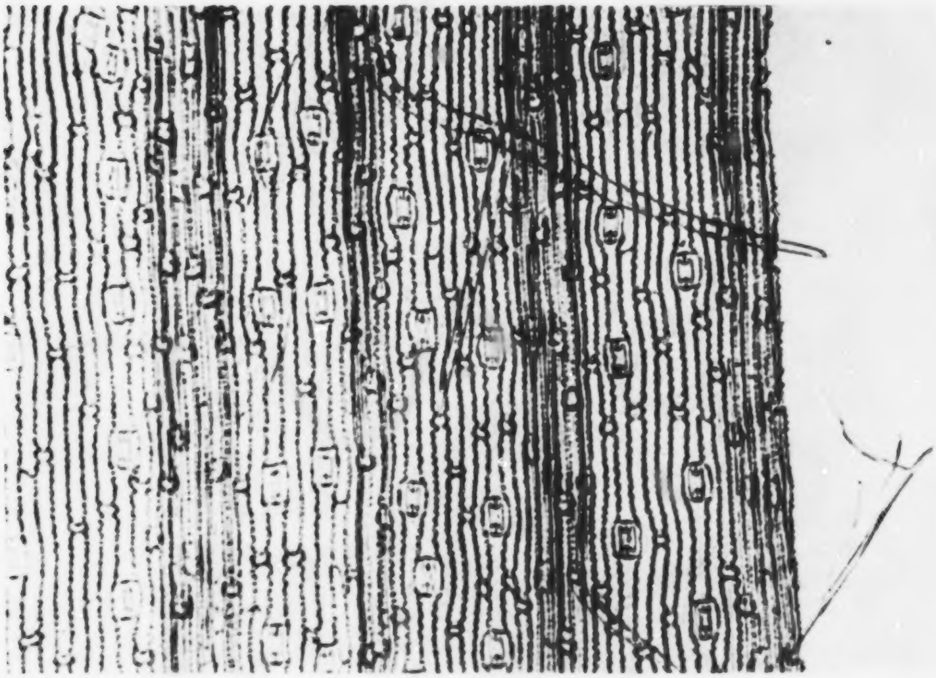

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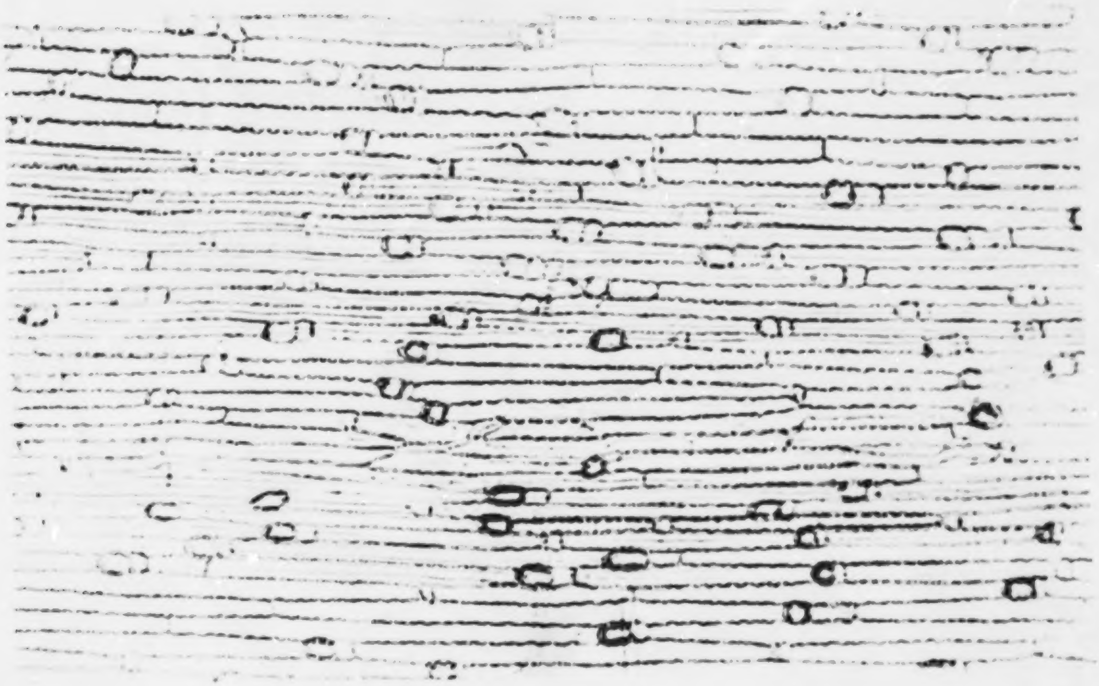

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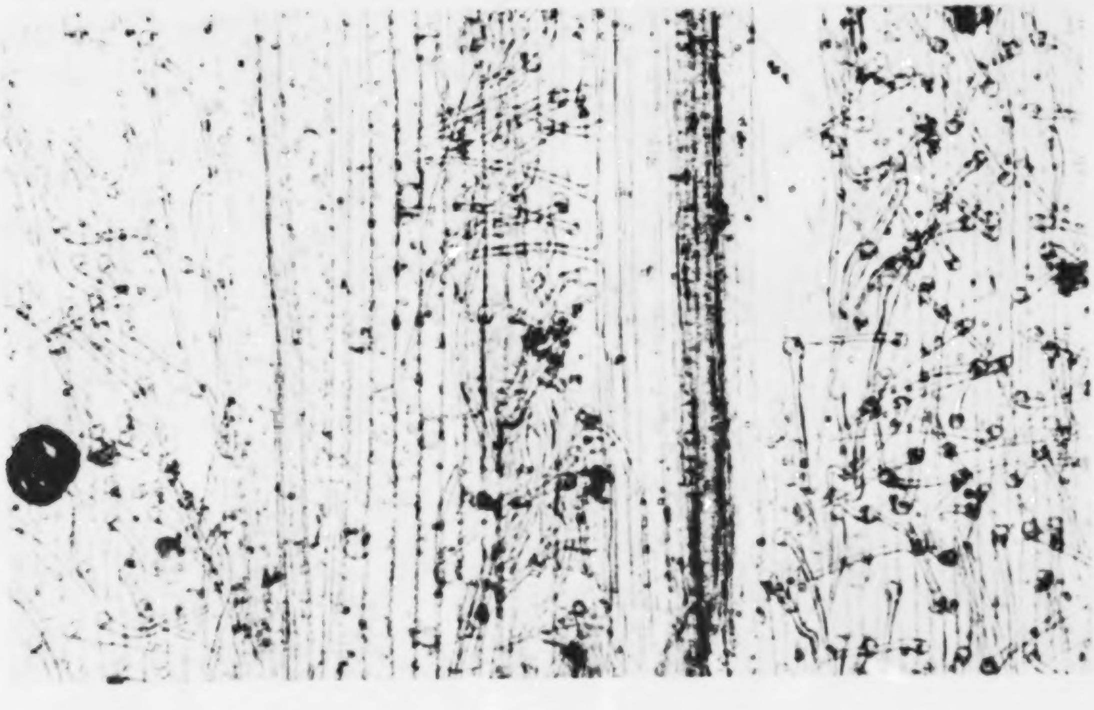

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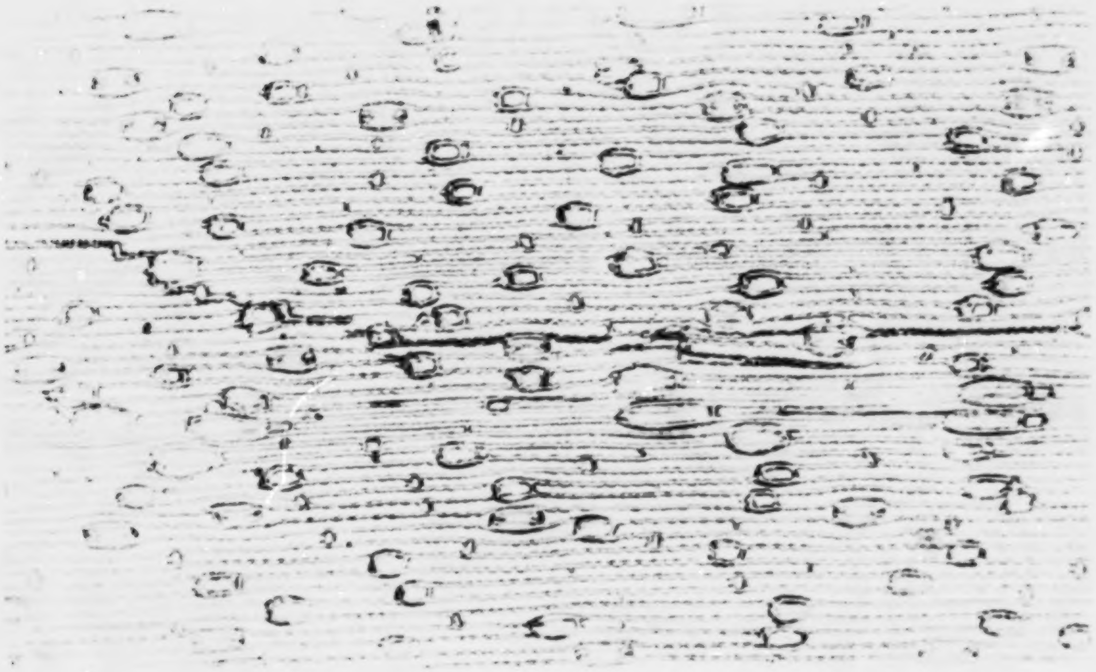

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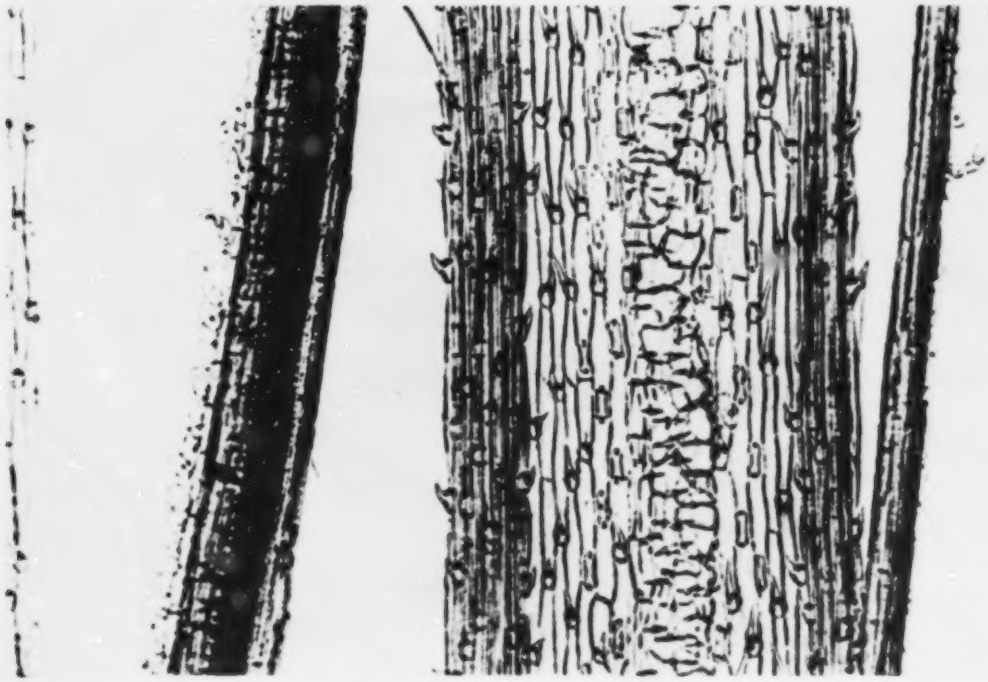
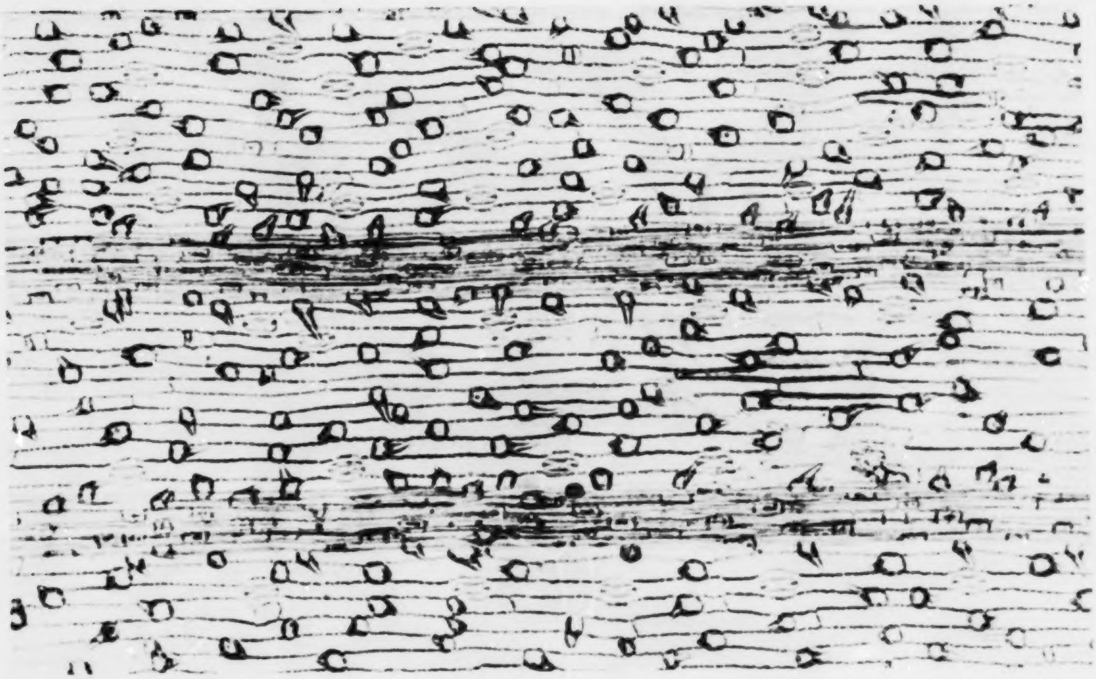


Koeleria cristata (24)



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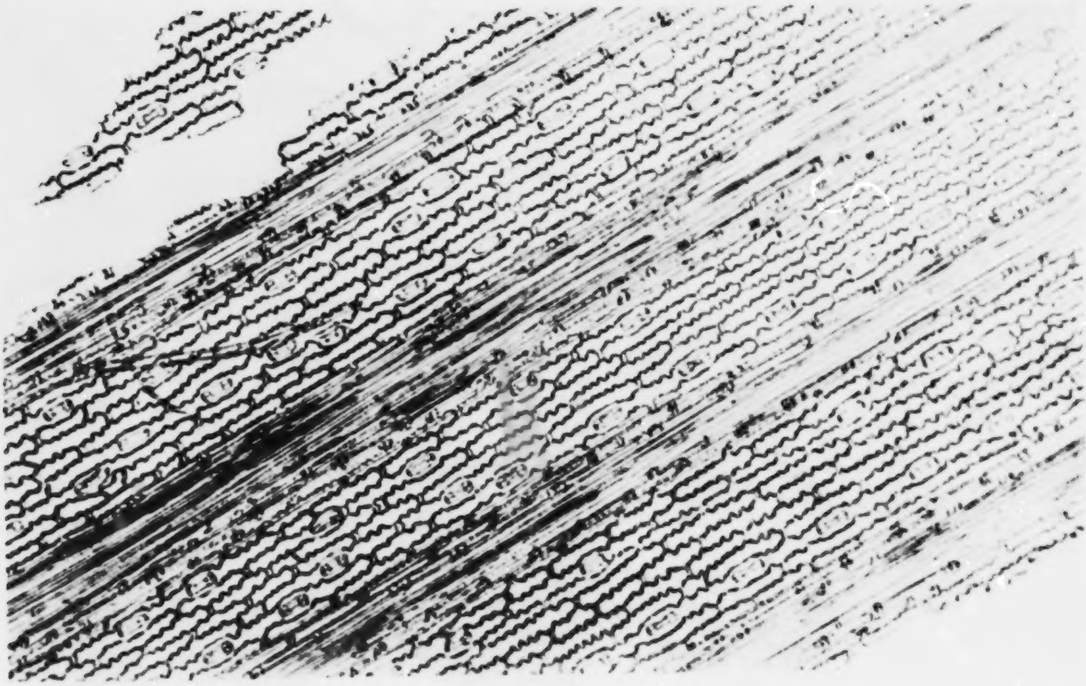

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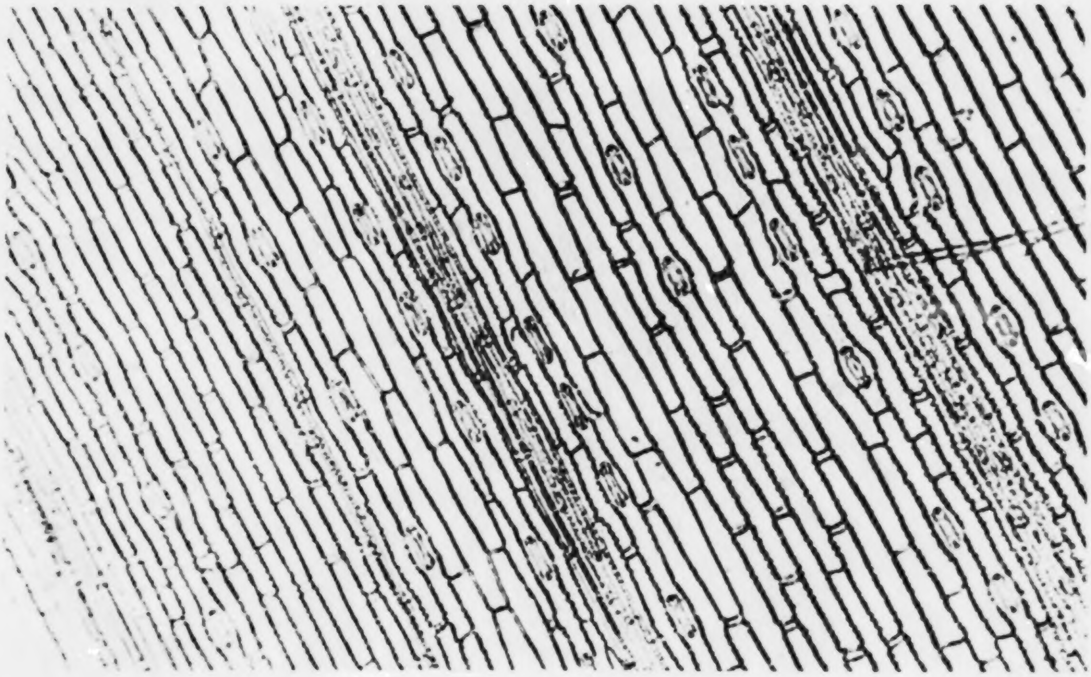

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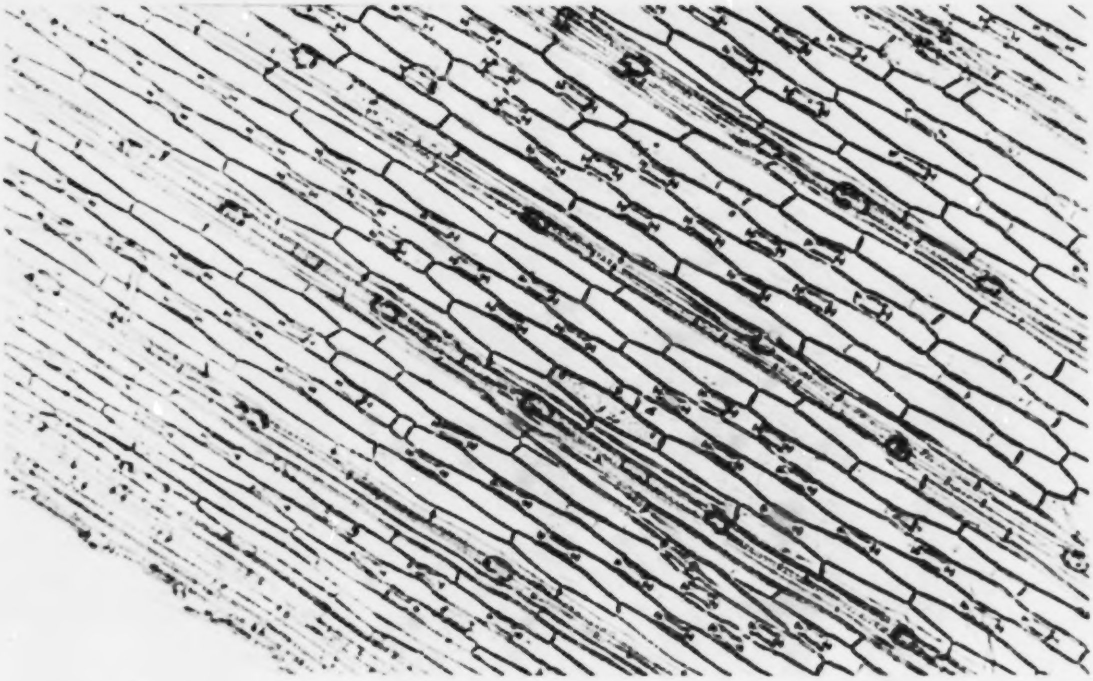

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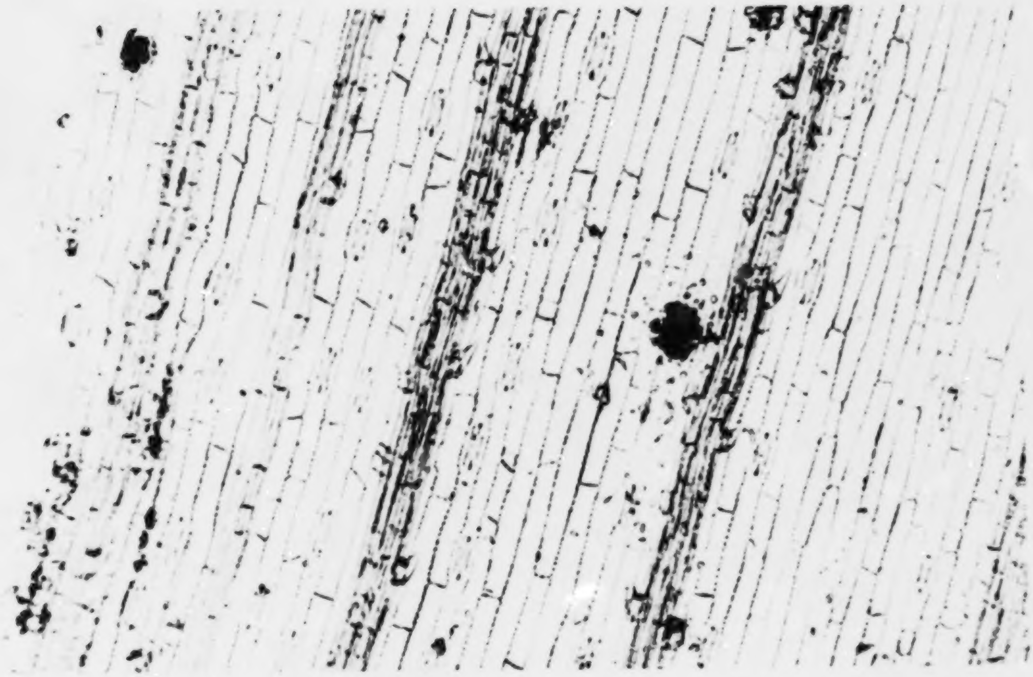

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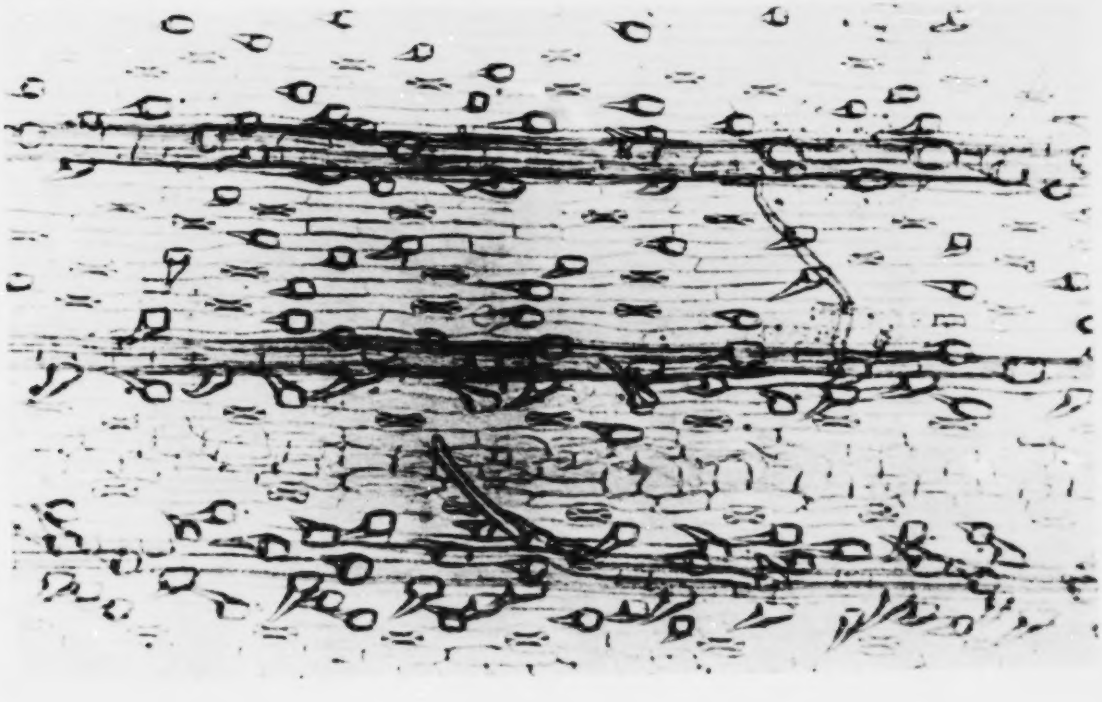

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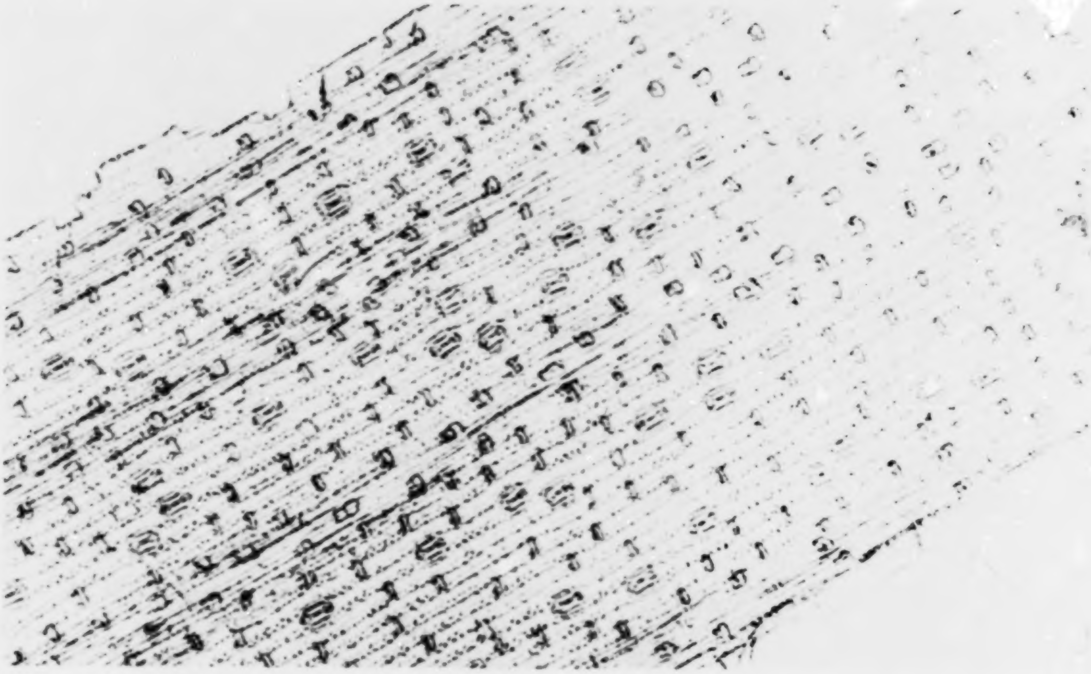
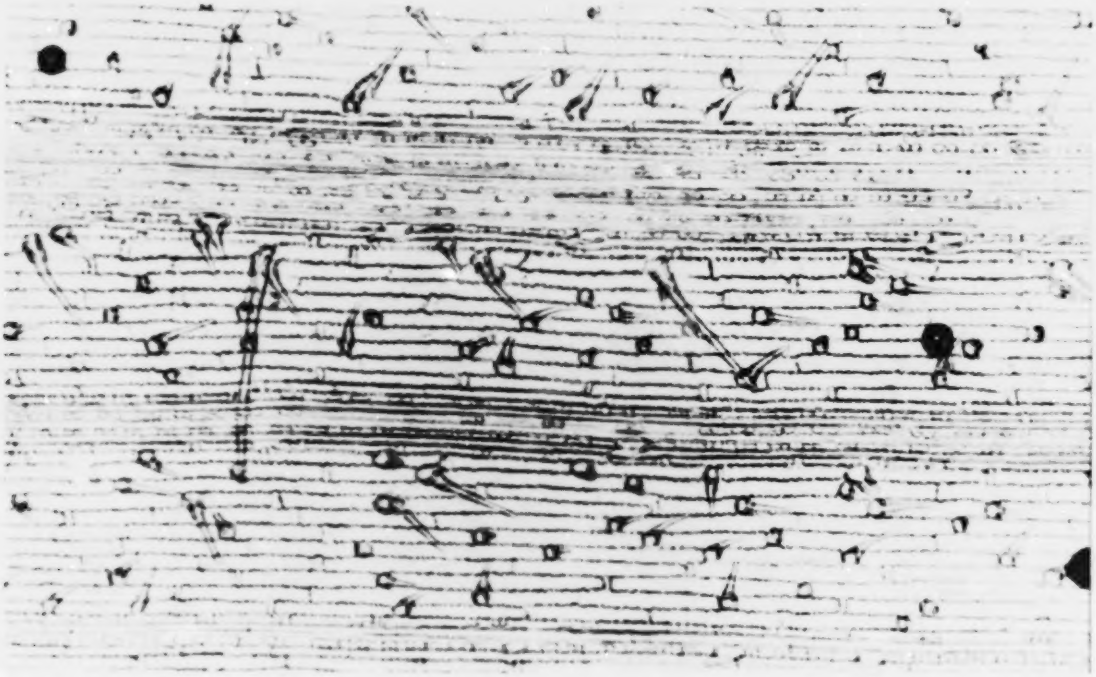
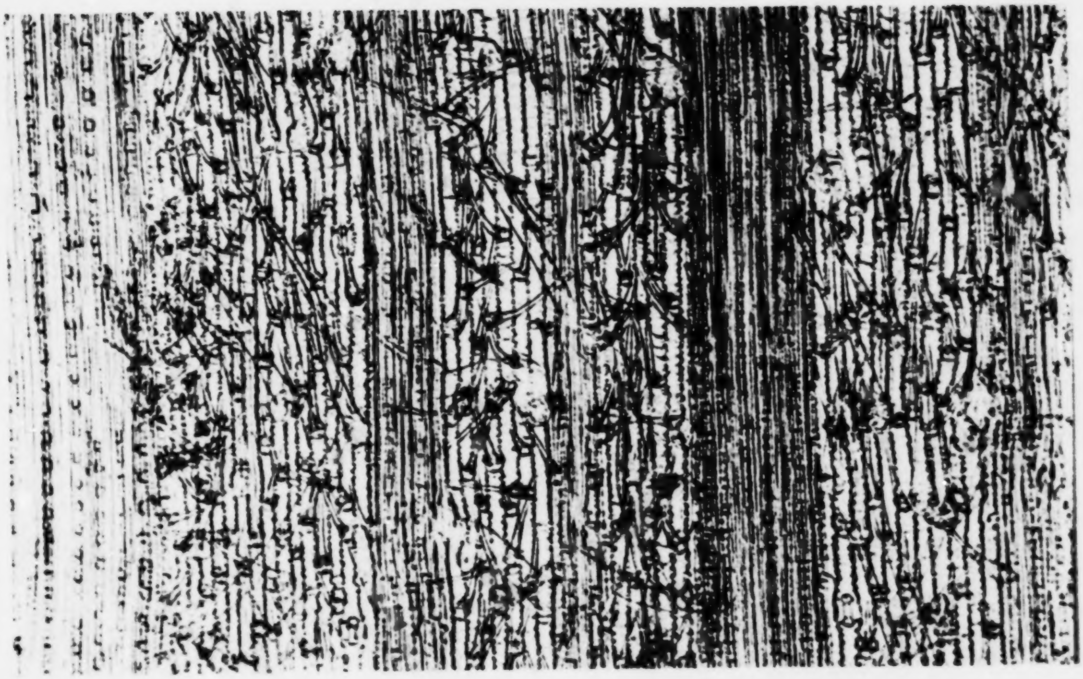


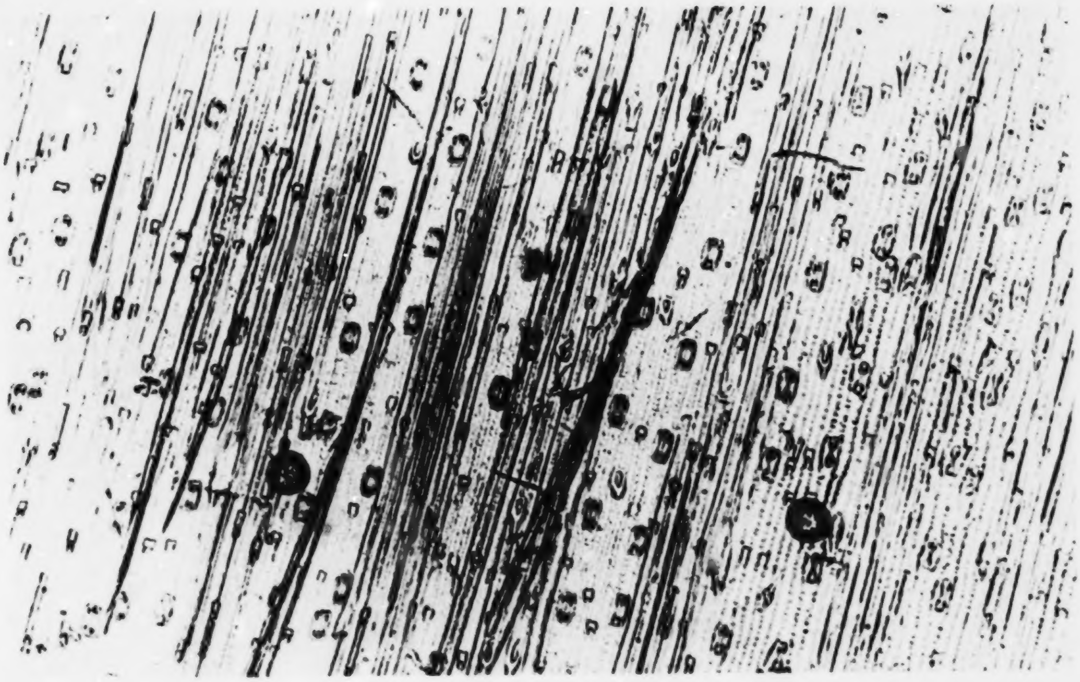
Poa sandbergii (31)



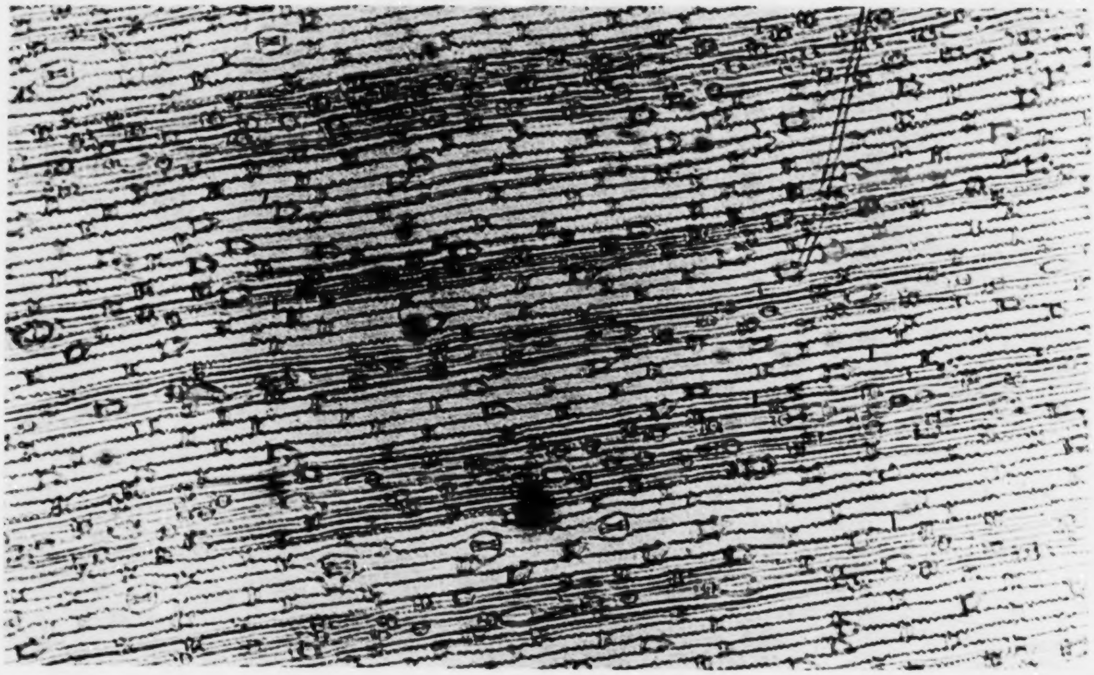
Stipa occidentalis (32)



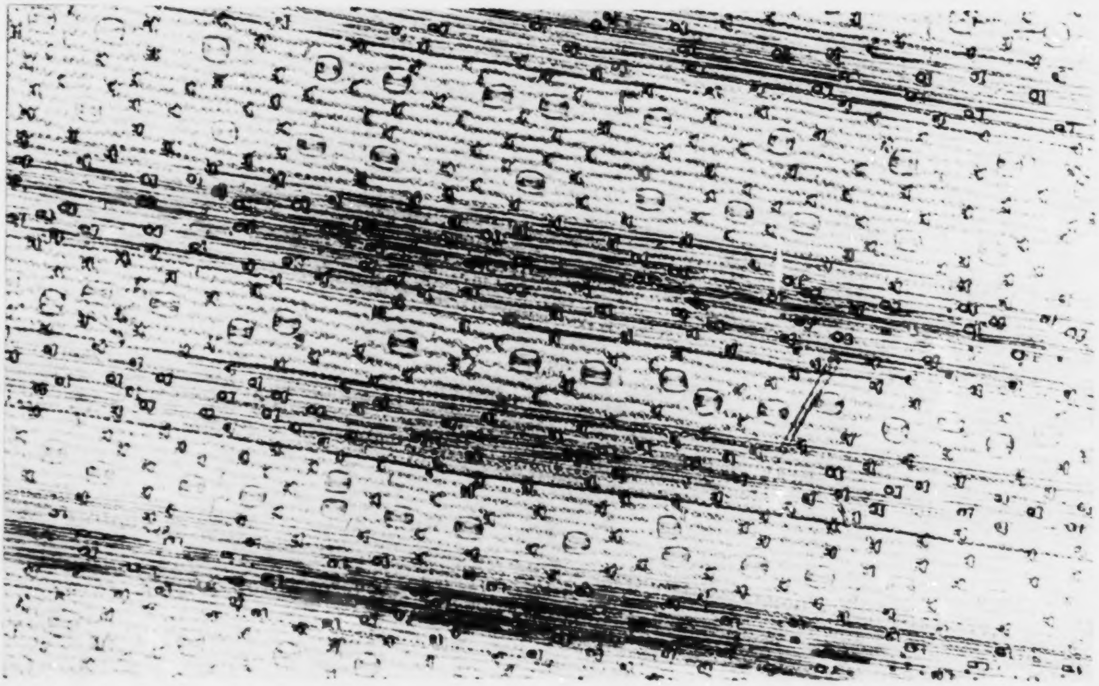
Stipa occidentalis (33)



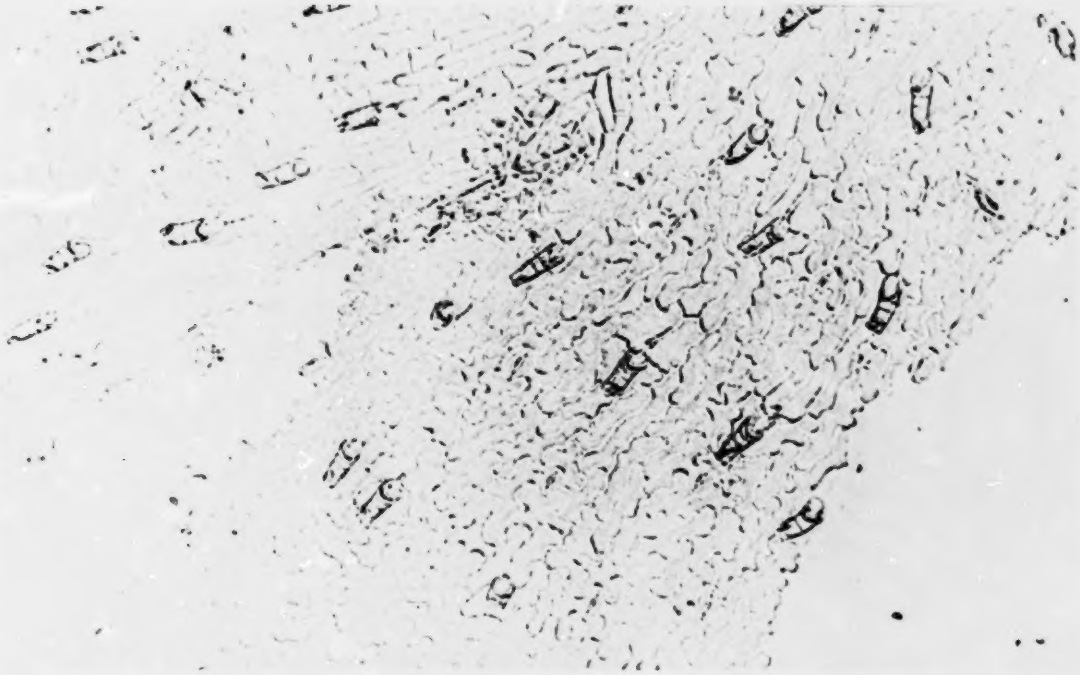
Stipa occidentalis (34)



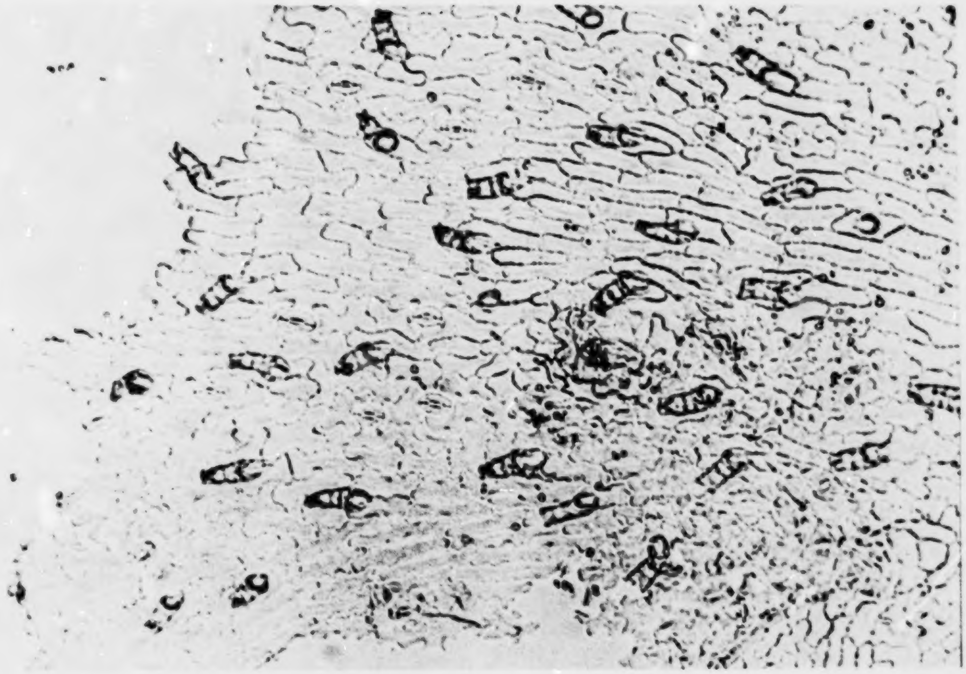
Stipa comata (35)



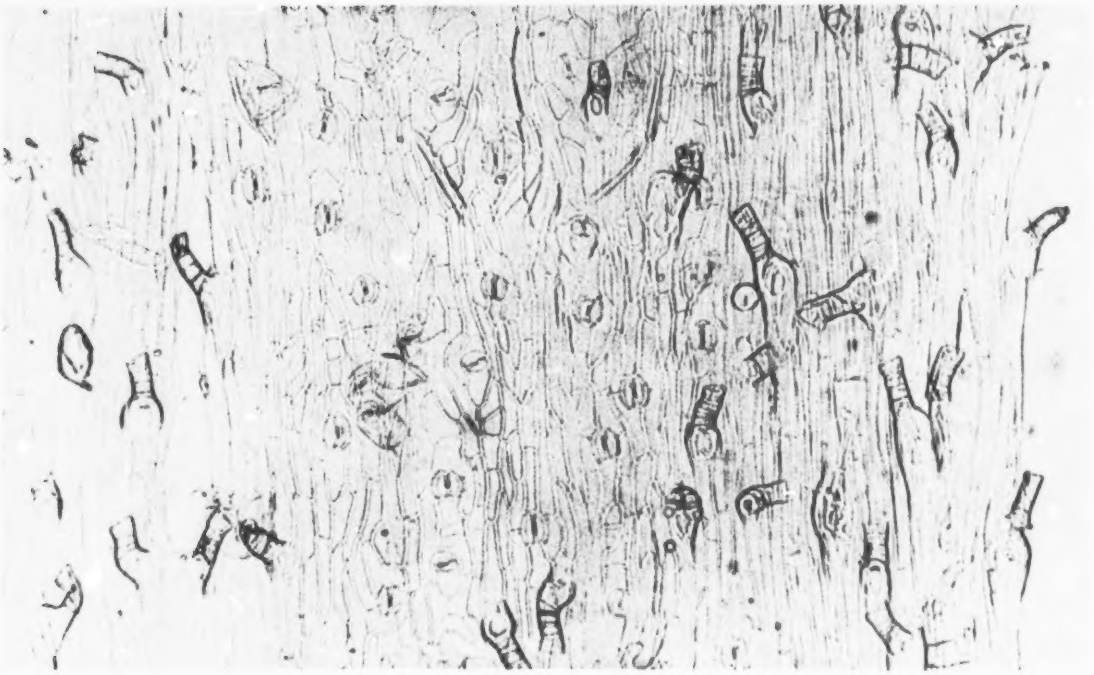
Stipa comata (36)



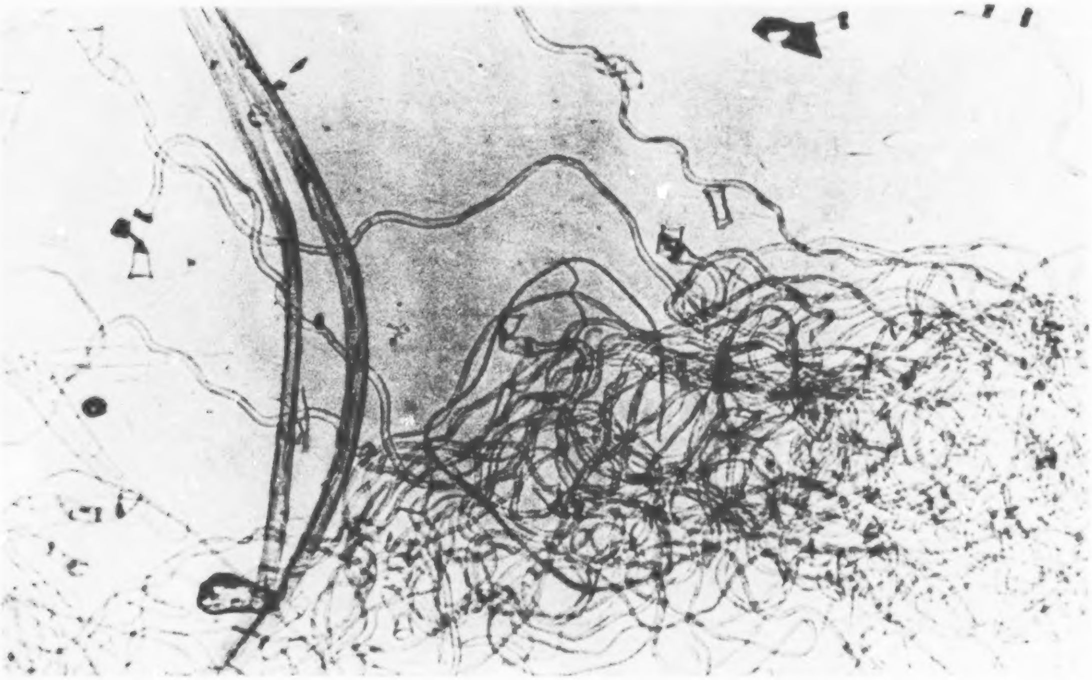
Achillea millefolium (37)



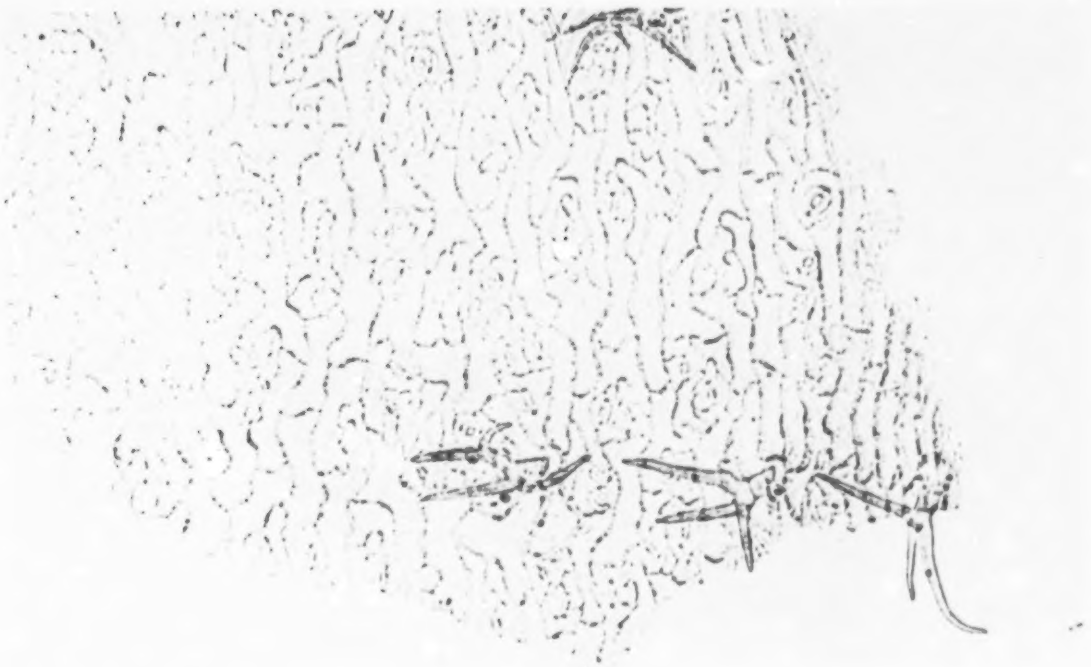
Achillea millefolium (38)



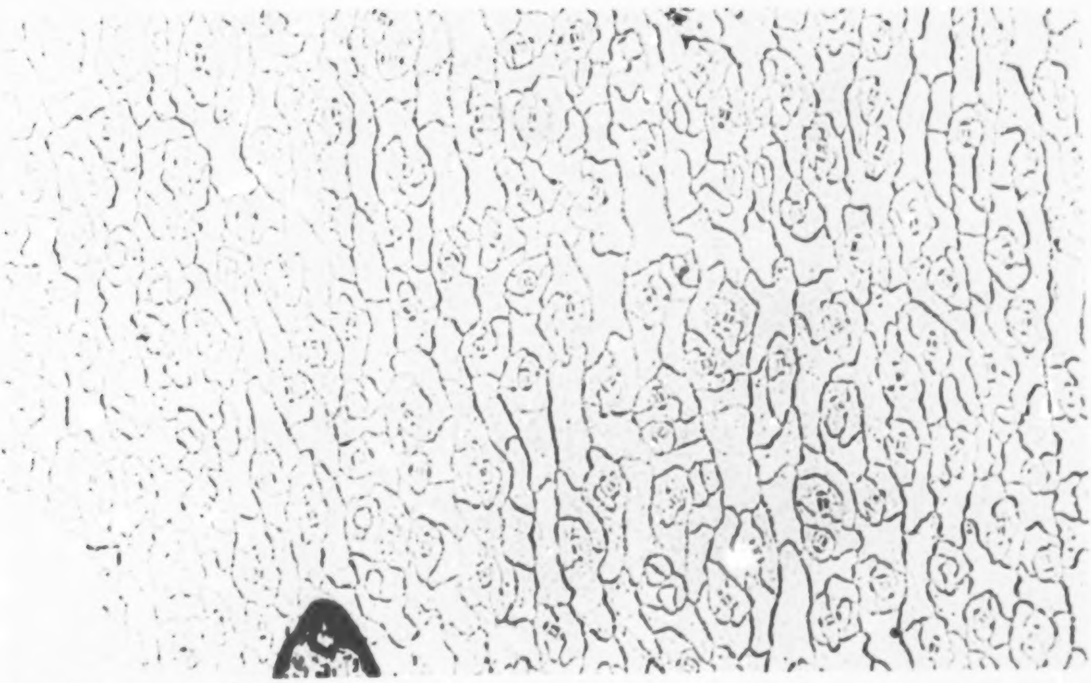
Achillea millefolium (39)



Antennaria parvifolia (40)

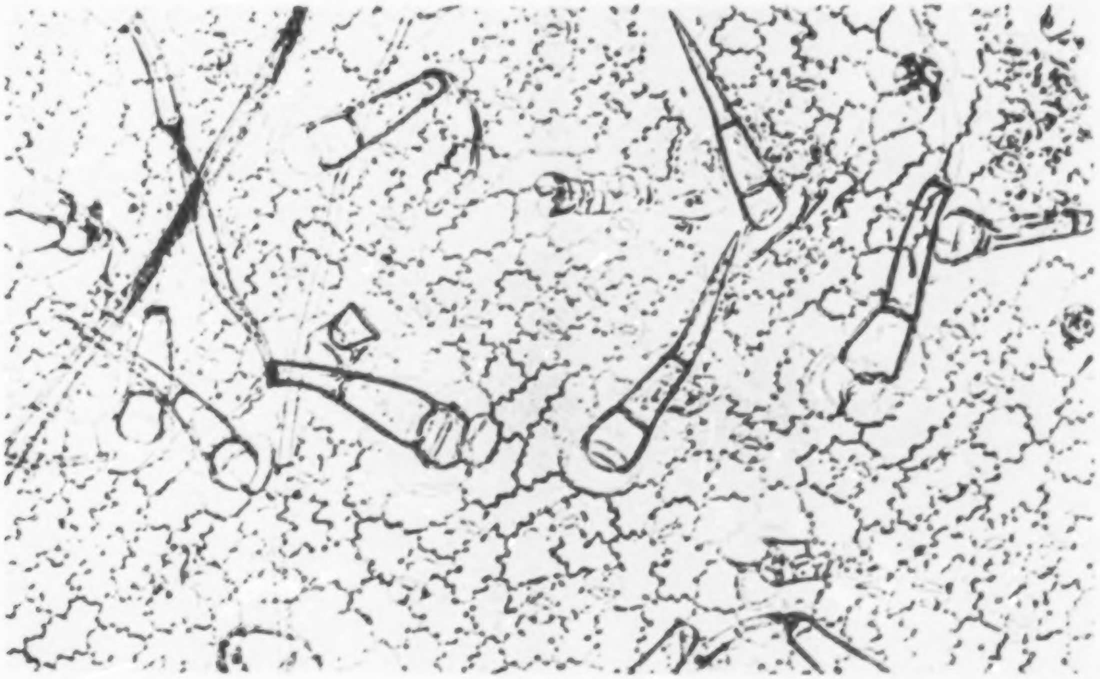


Arabis holboellii (41)

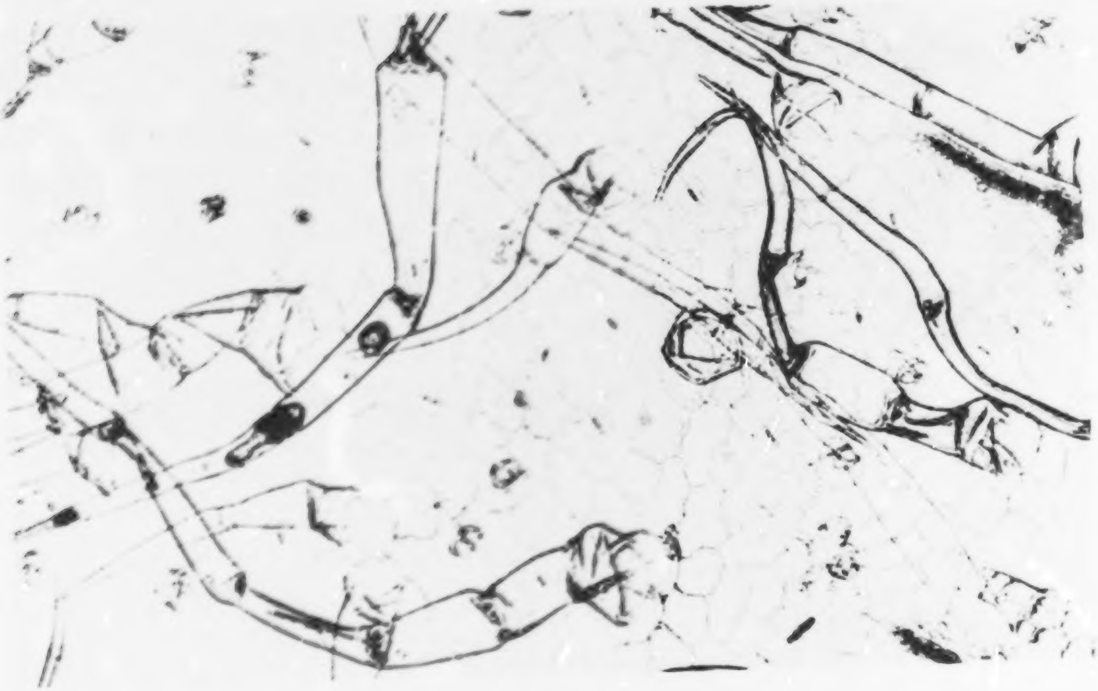


Arabis holboellii (42)

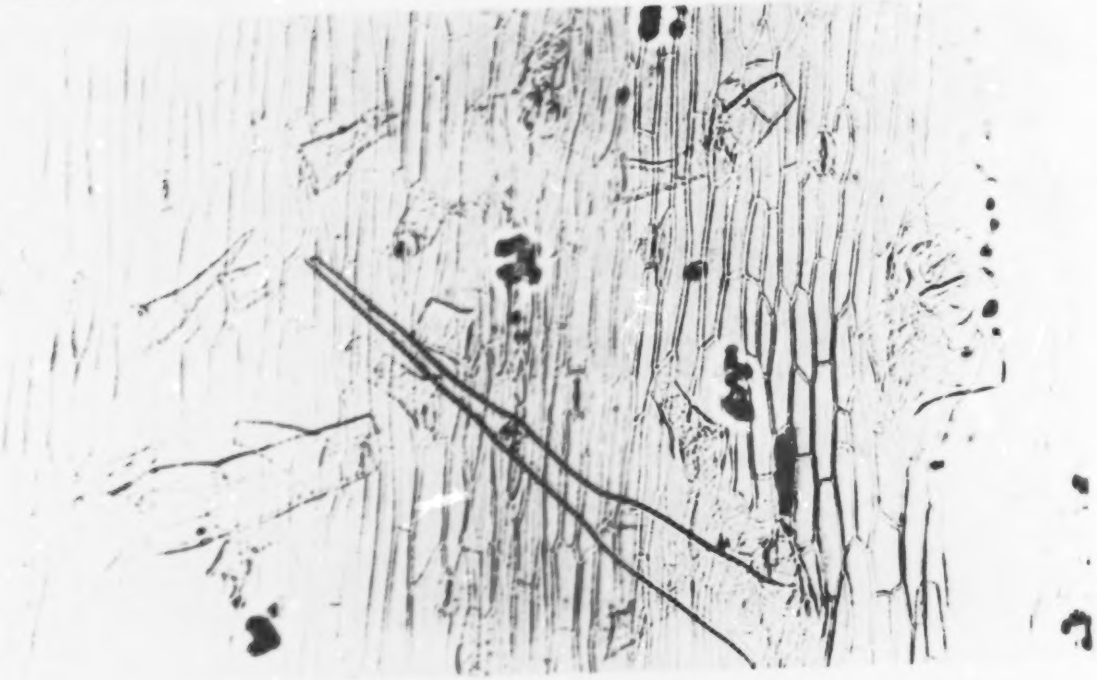
Arabis holboellii (43)



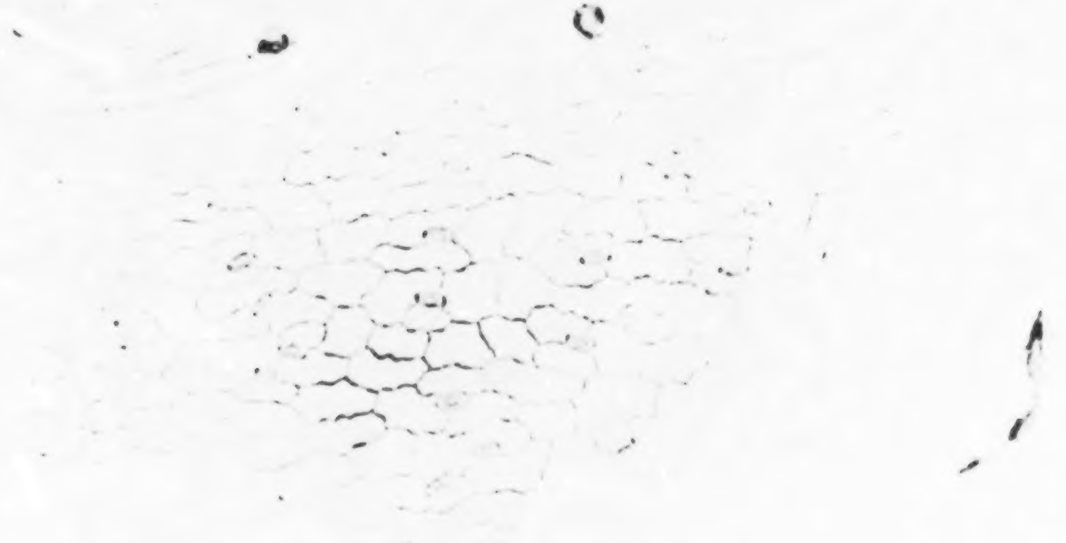
Arnica sororia (44)



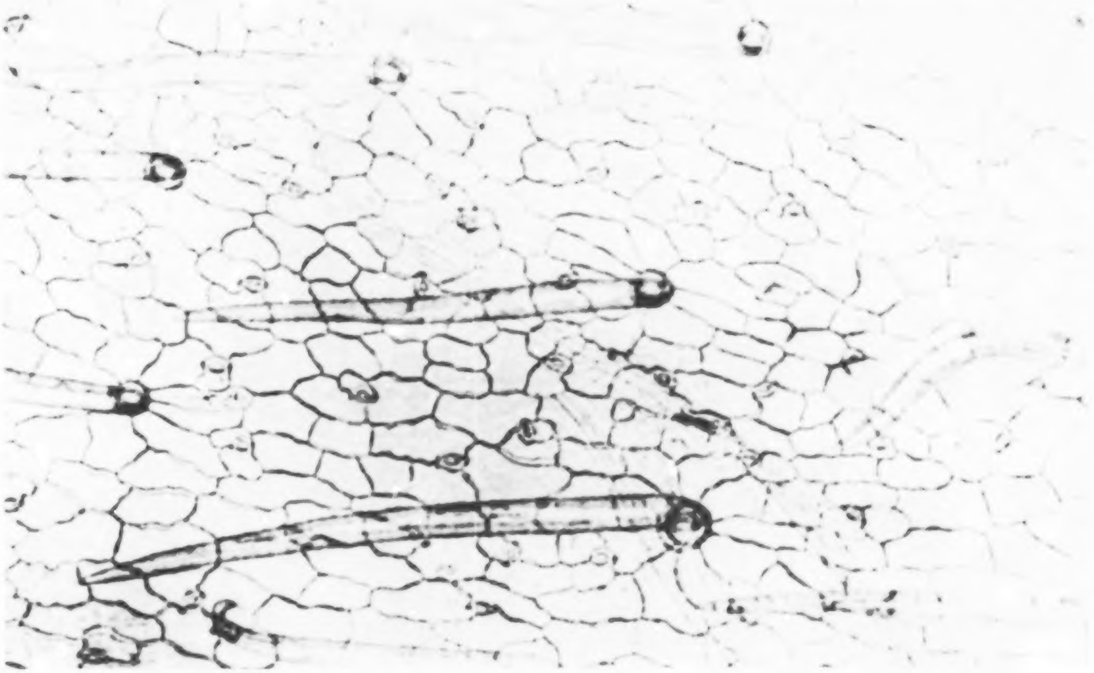
Arnica sororia (45)



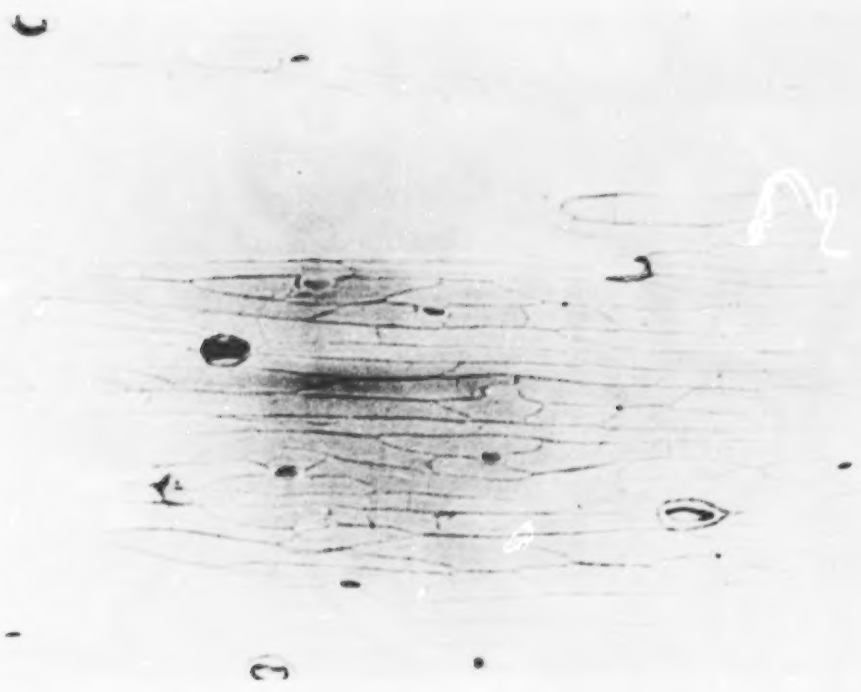
Arnica sororia (46)



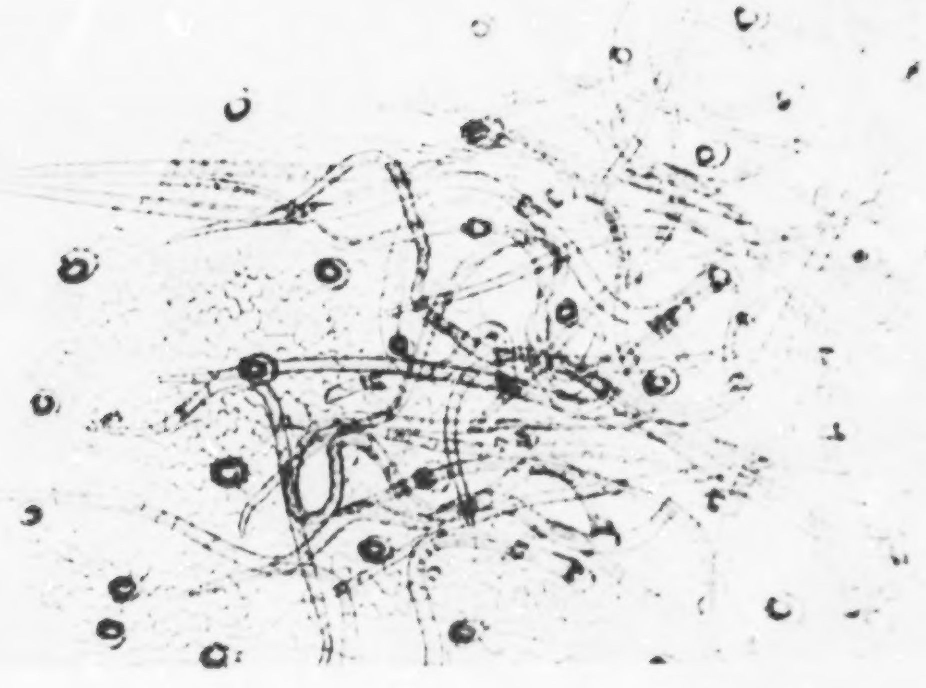
Astragalus miser (47)



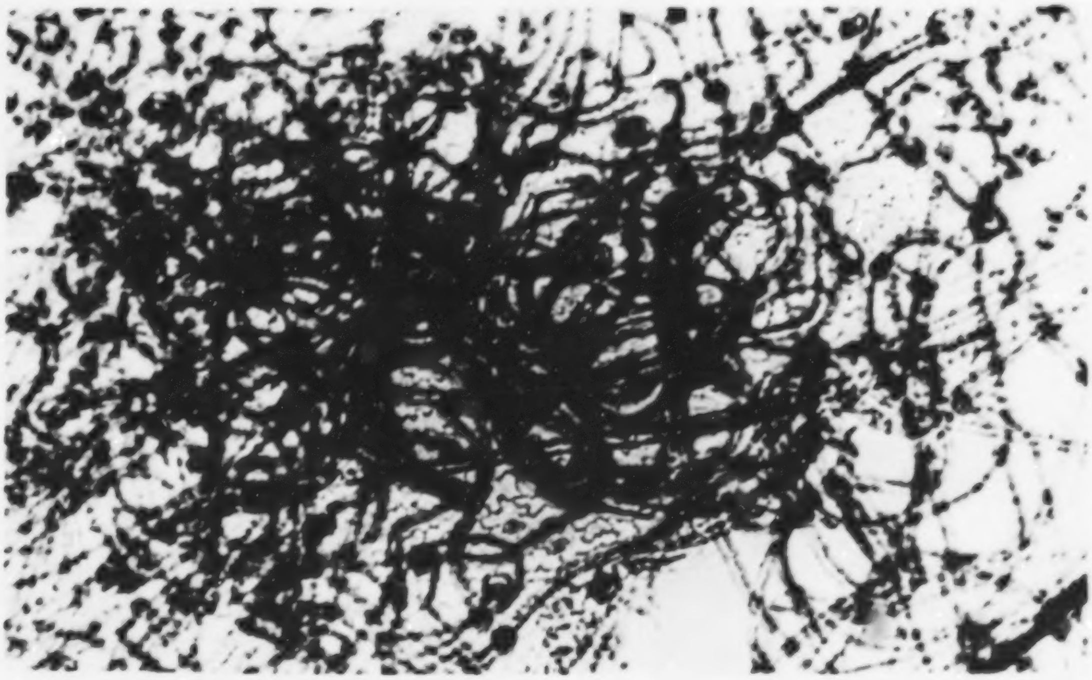
Astragalus miser (48)



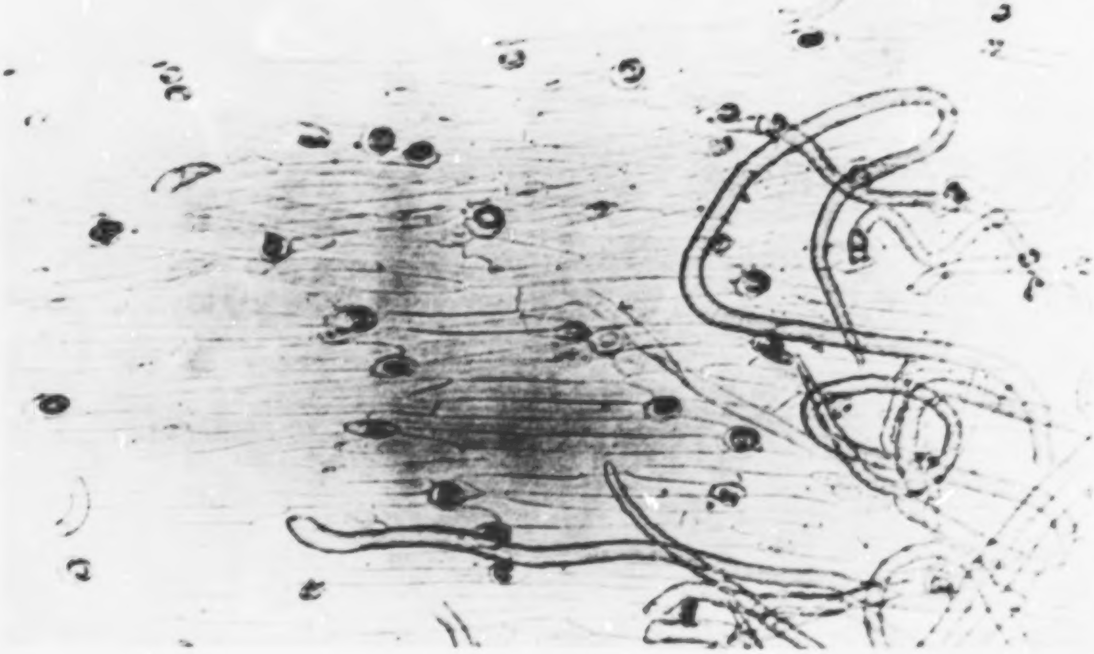
Astragalus miser (49)



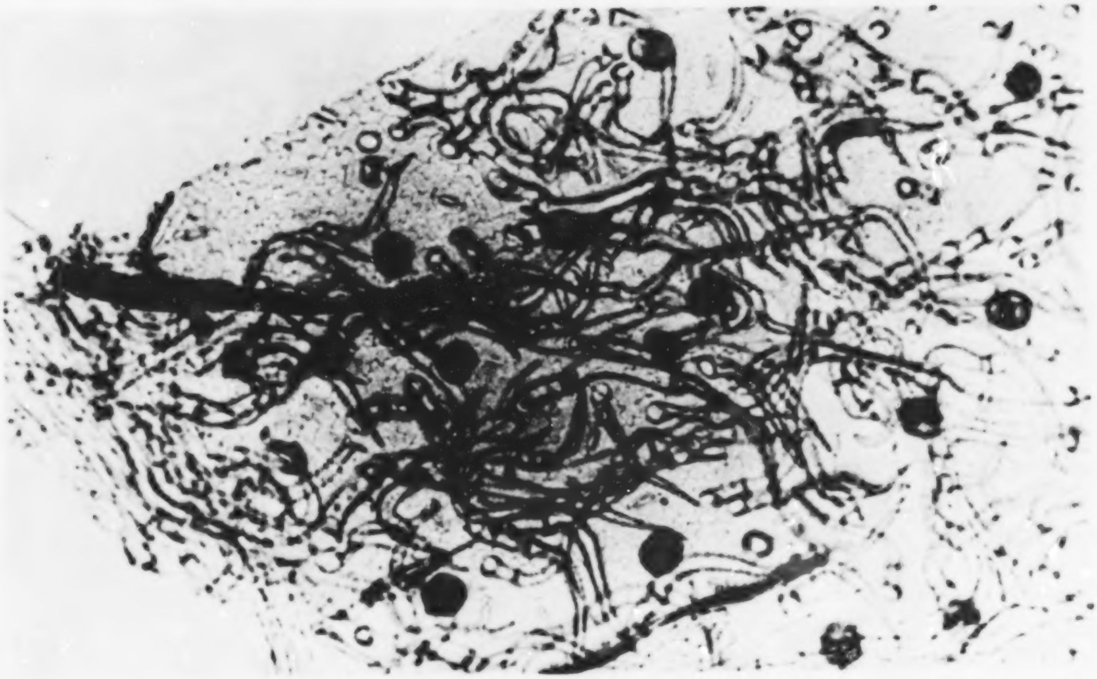
Astragalus purshii (50)



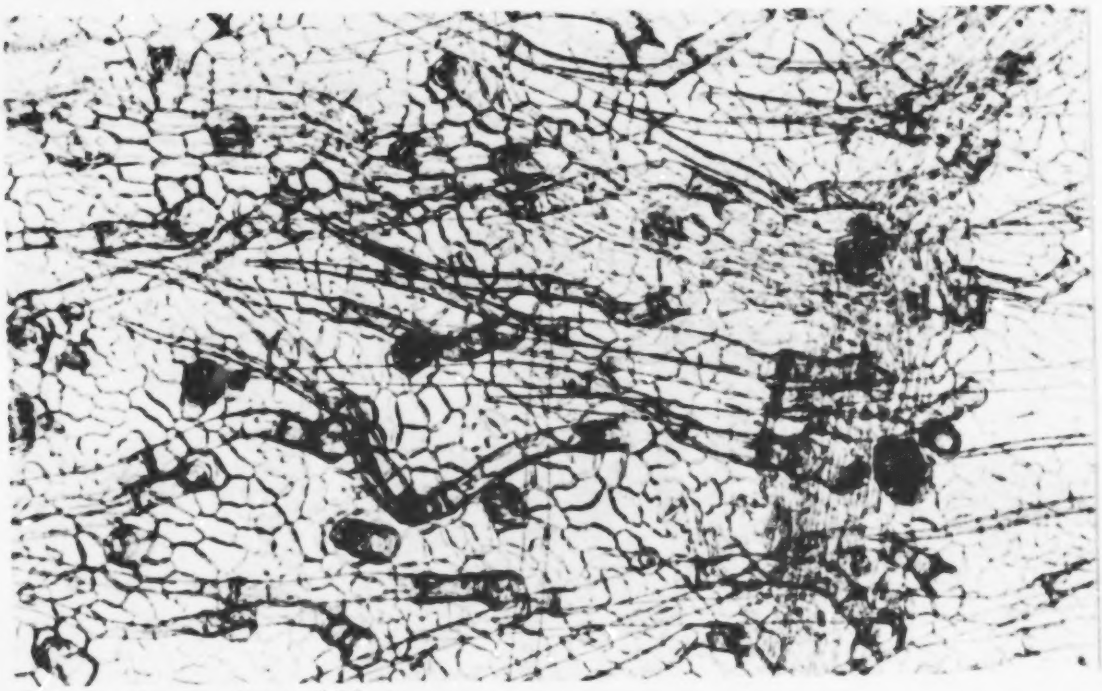
Astragalus purshii (51)



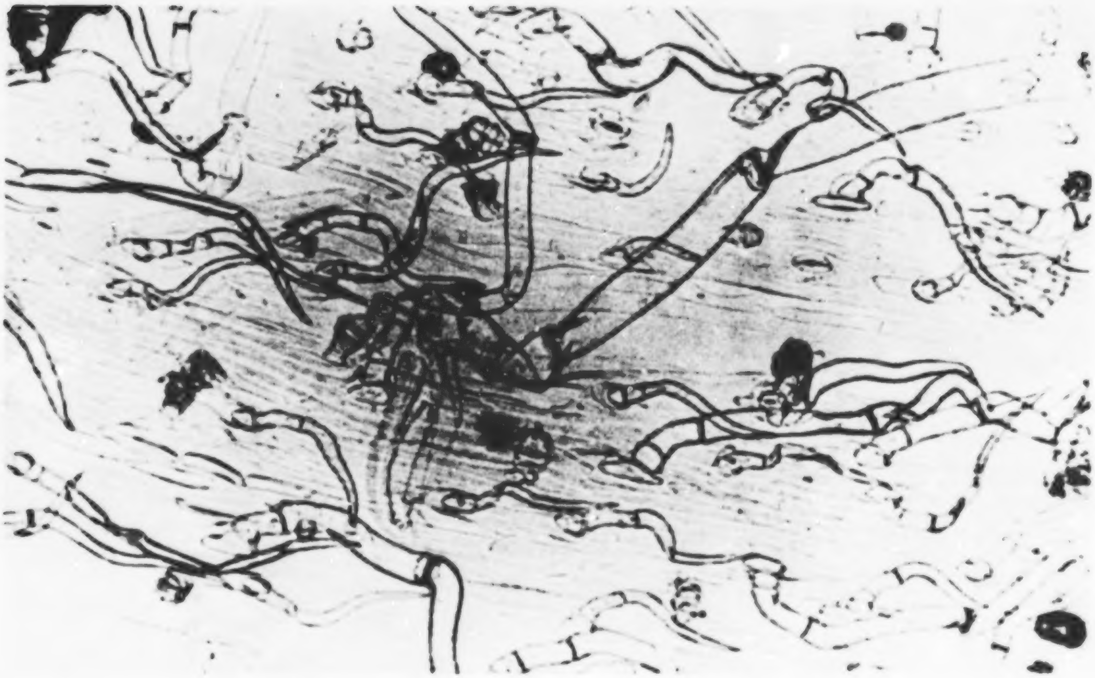
Astragalus purshii (52)



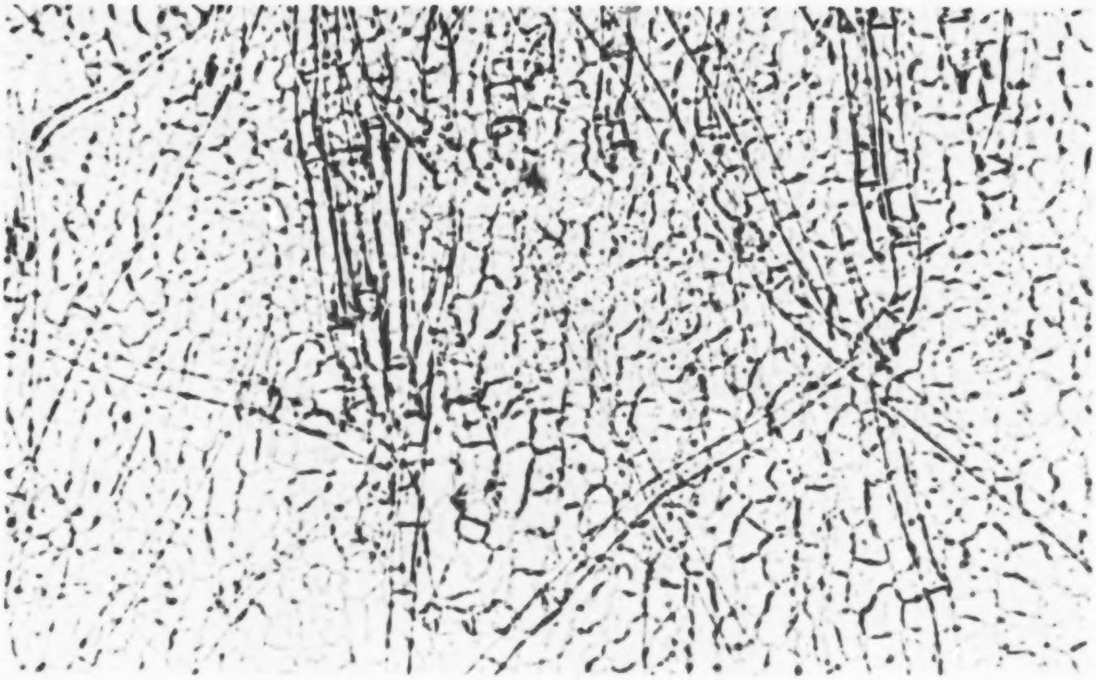
Balsamorhiza sagittata (53)



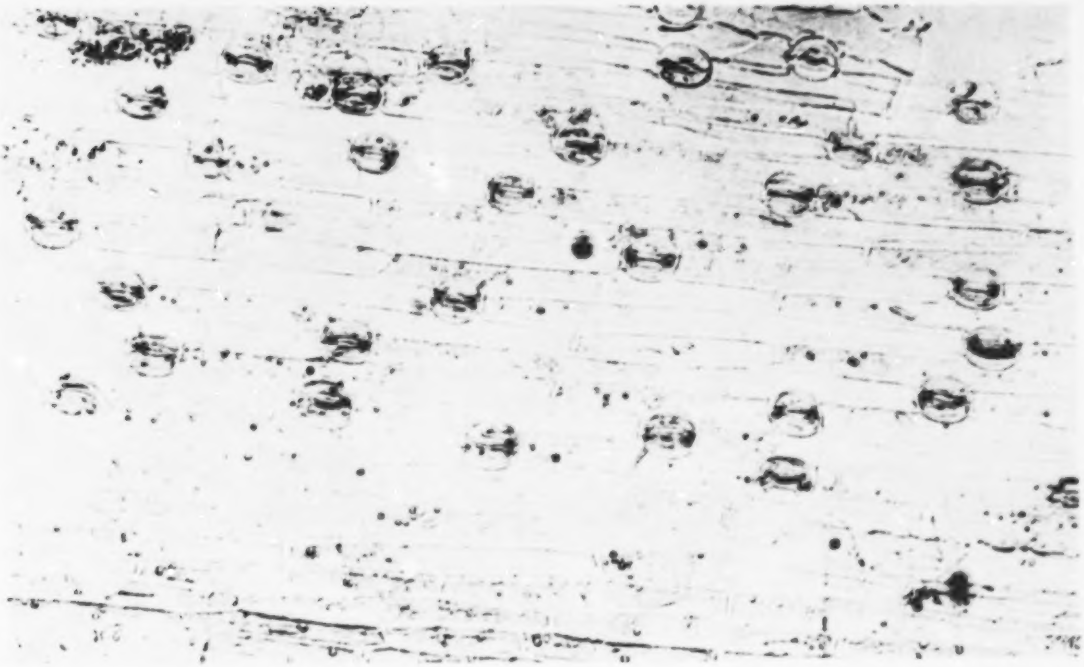
Balsamorhiza sagittata (54)



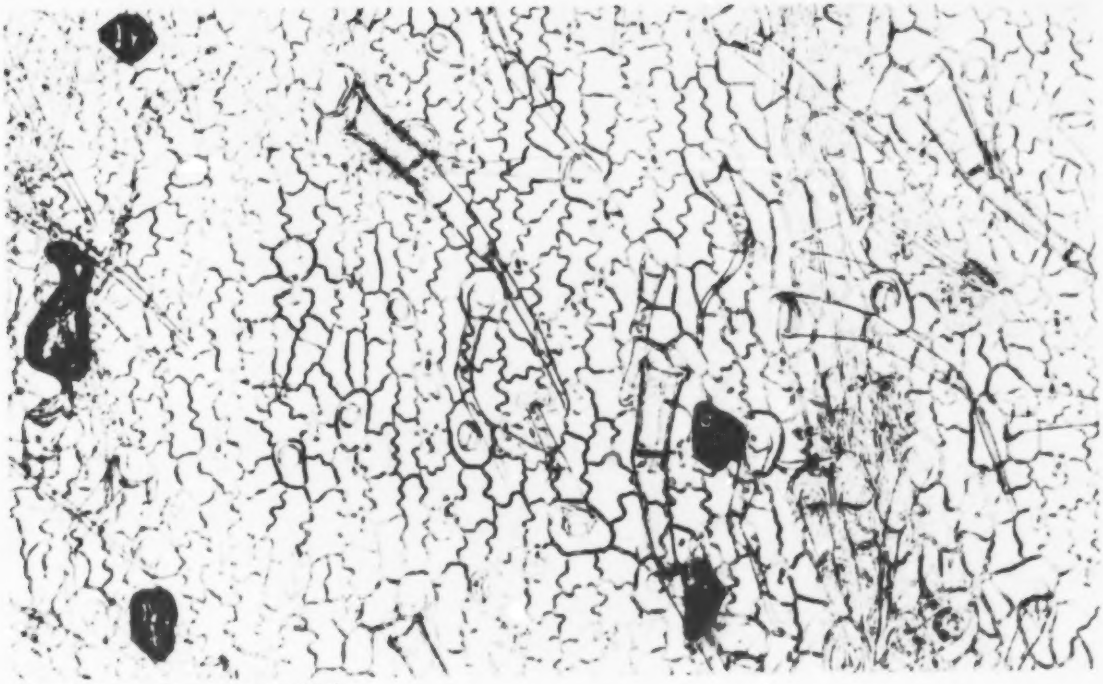
Balsamorhiza sagittata (55)



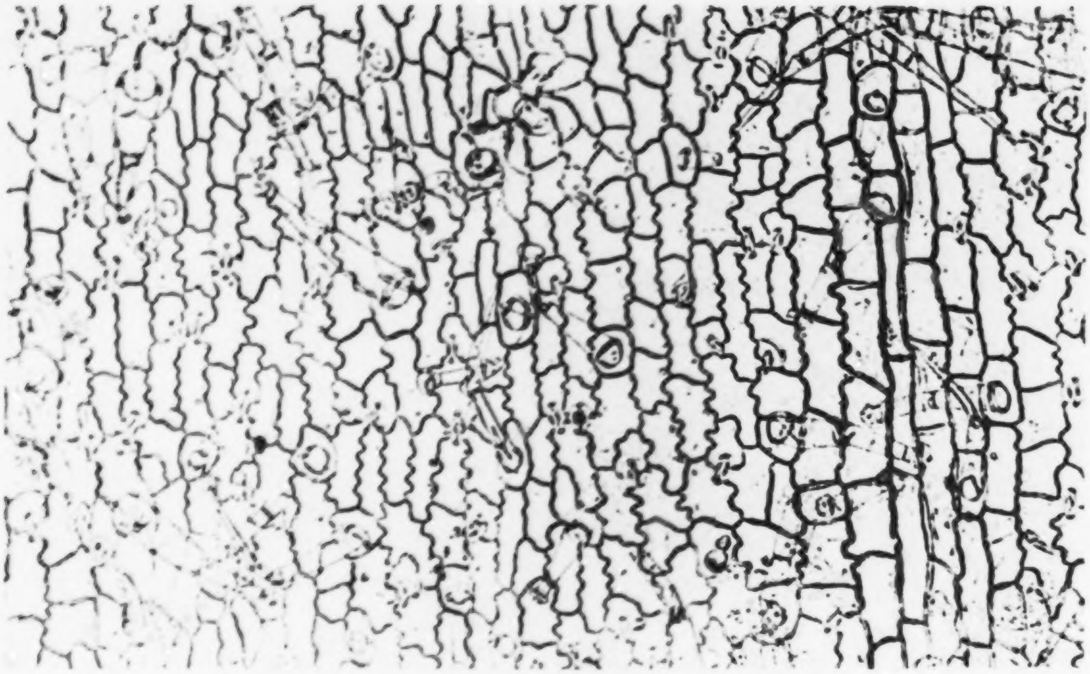
Balsamorhiza sagittata (56)



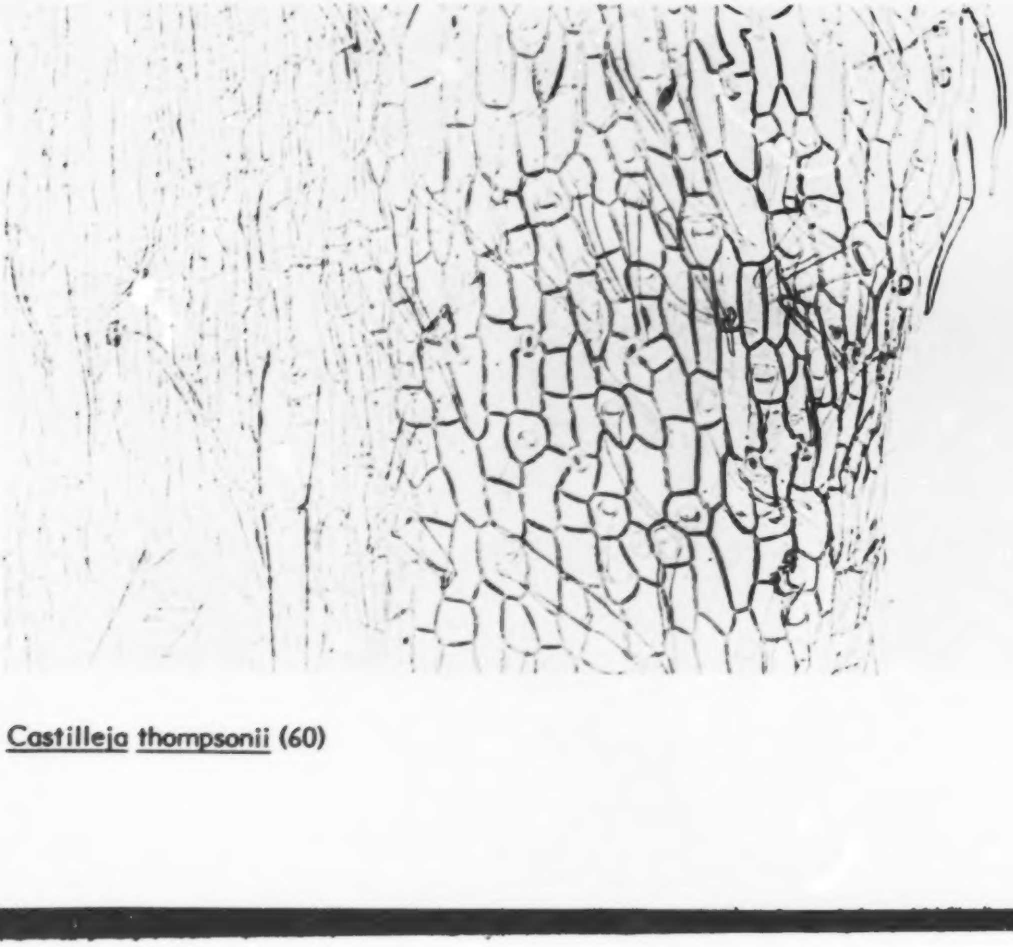
Calochortus macrocarpus (57)



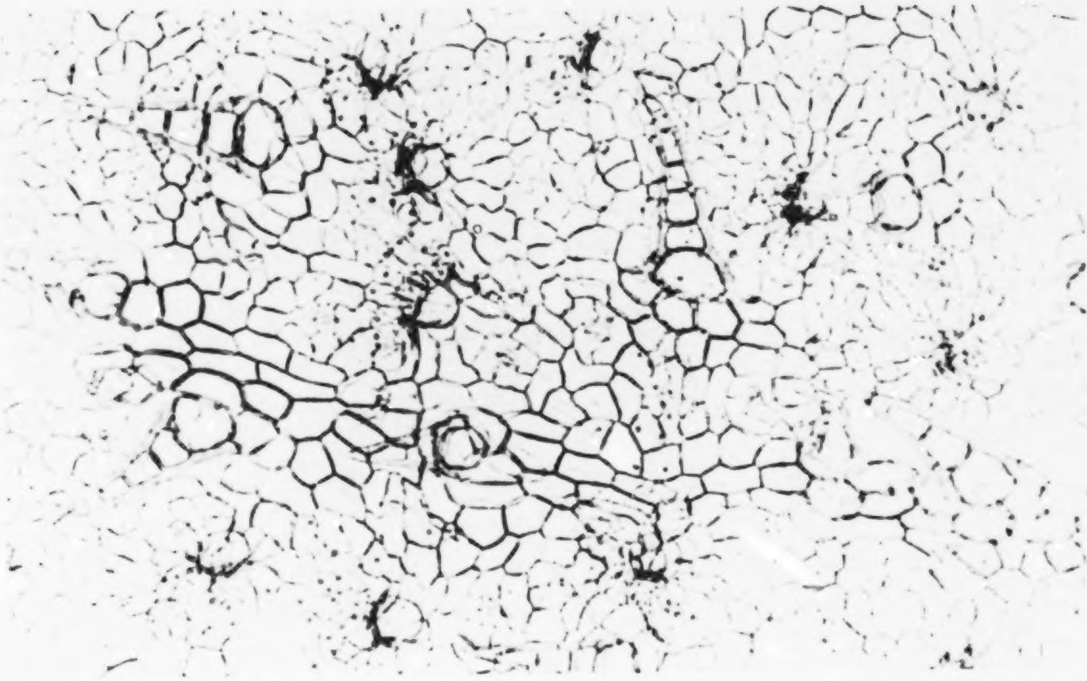
Castilleja thompsonii (58)



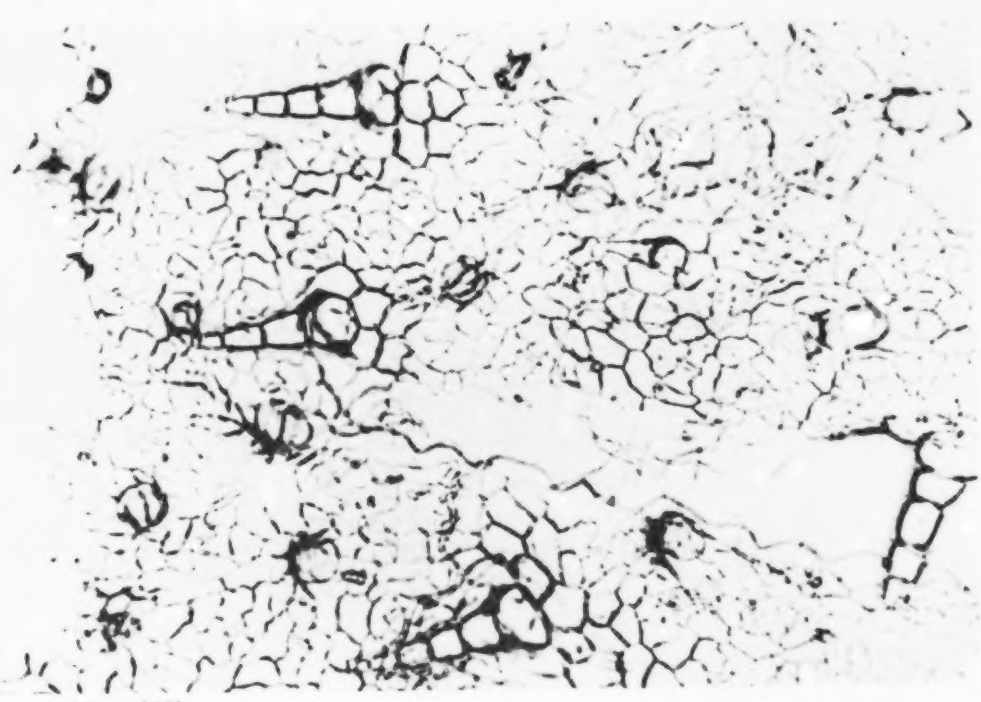
Castilleja thompsonii (59)



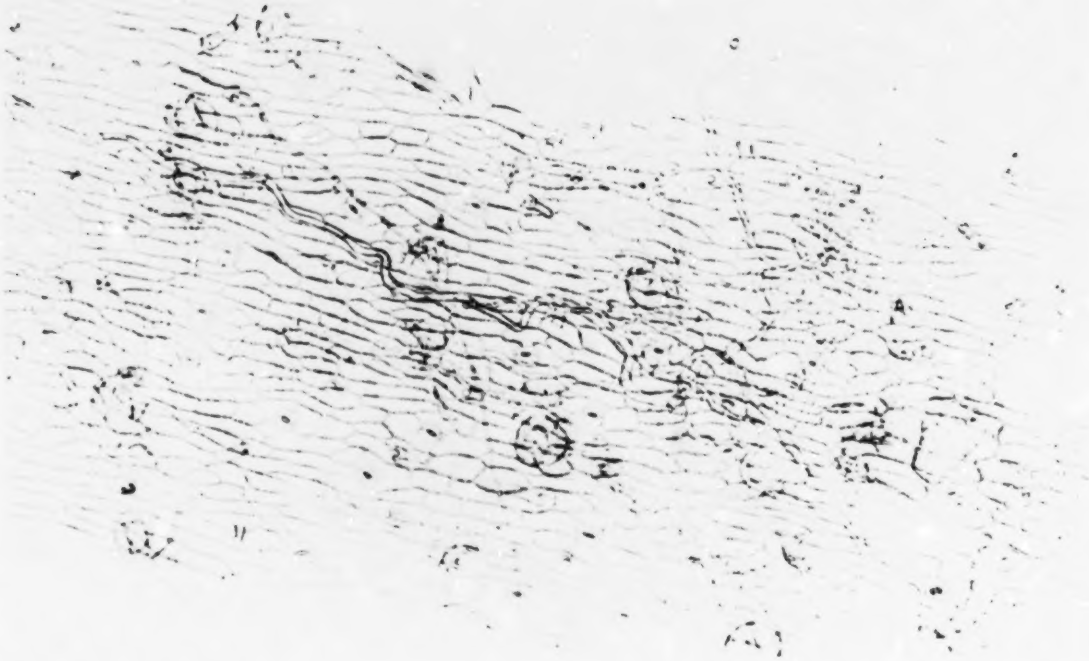
Castilleja thompsonii (60)



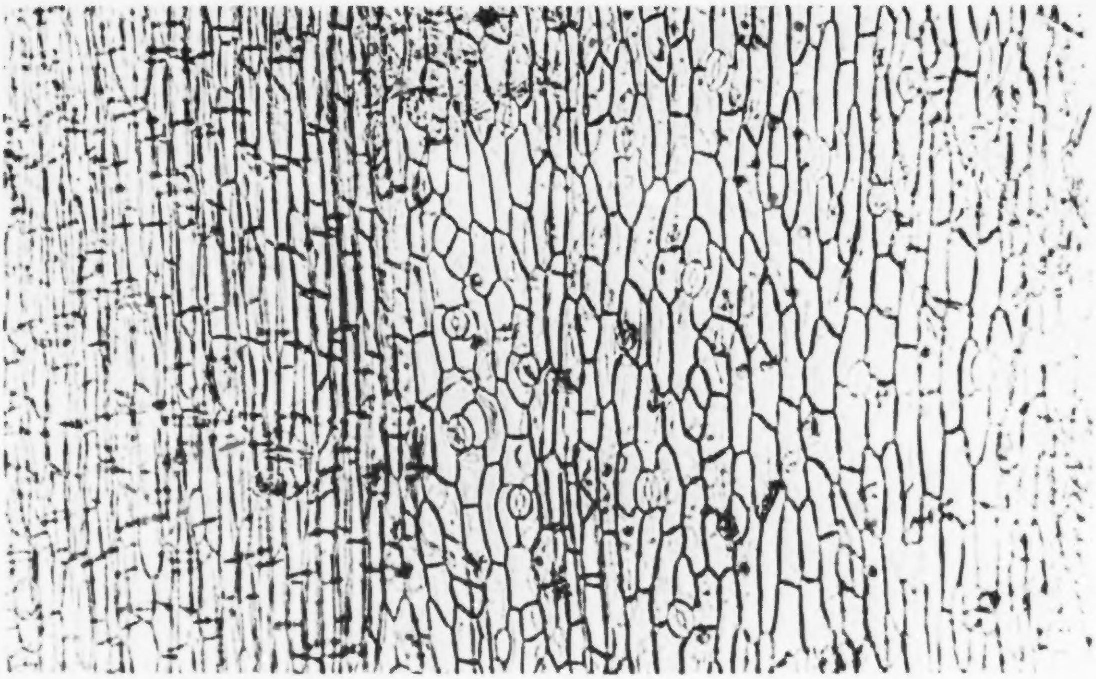
Centaurea diffusa (61)



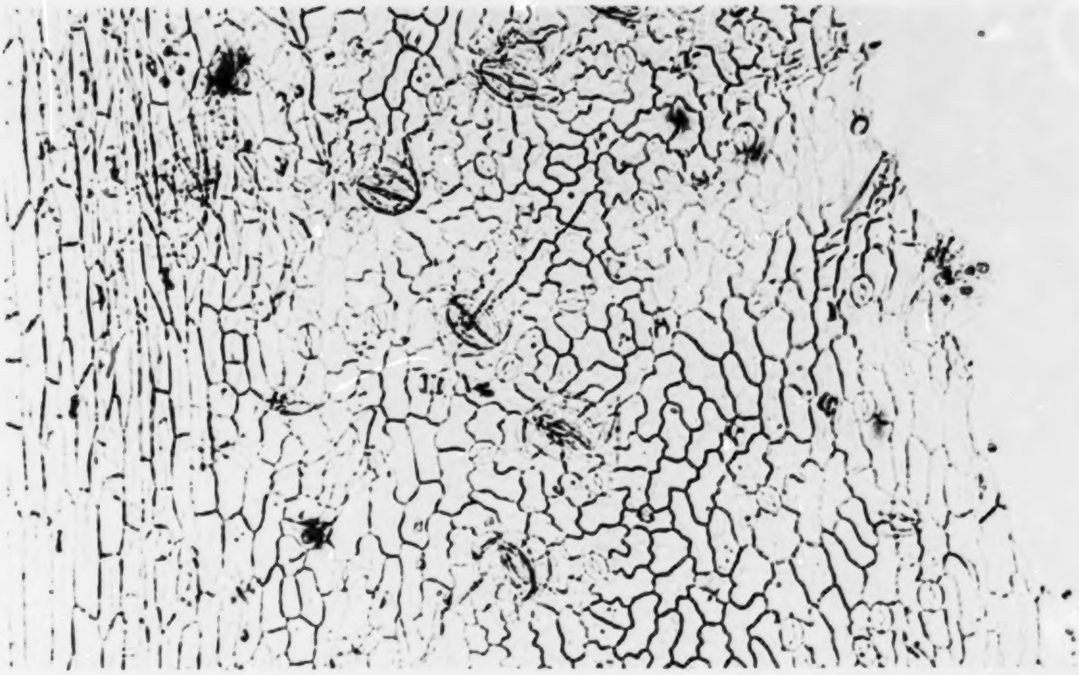
Centaurea diffusa (62)



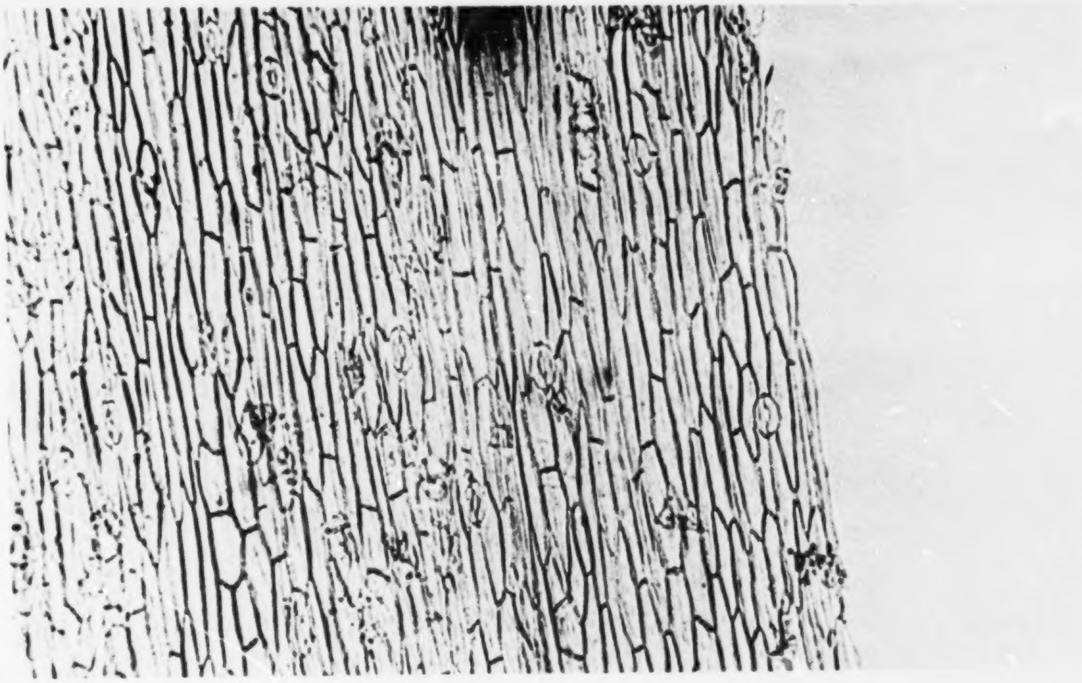
Centaurea diffusa (63)



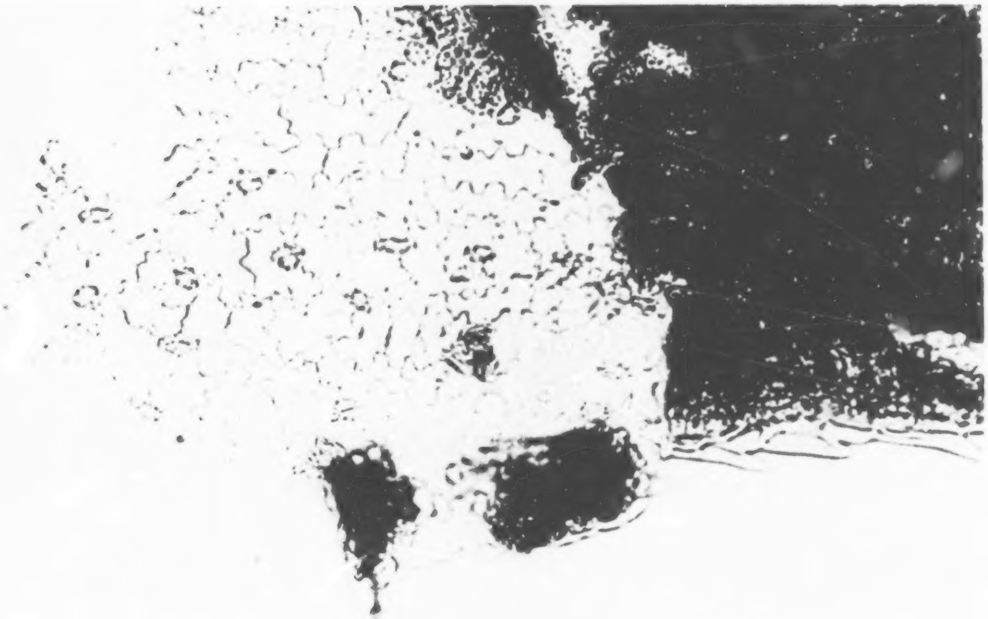
Chaenactis douglasii (64)



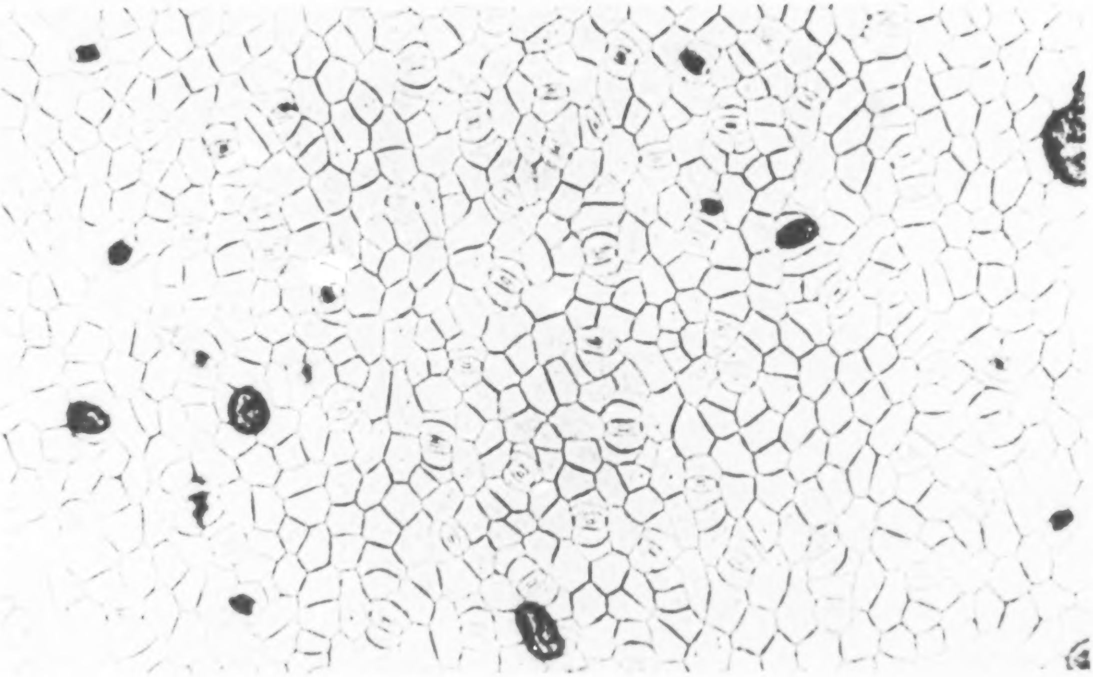
Chaenactis douglasii (65)



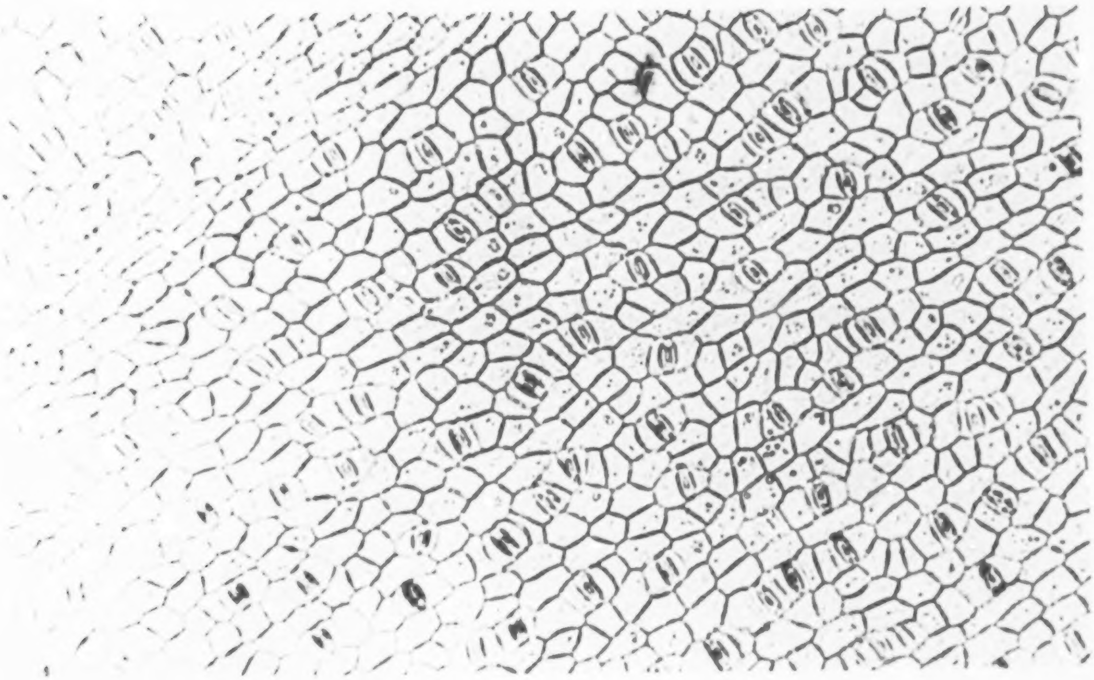
Chaenactis douglasii (66)



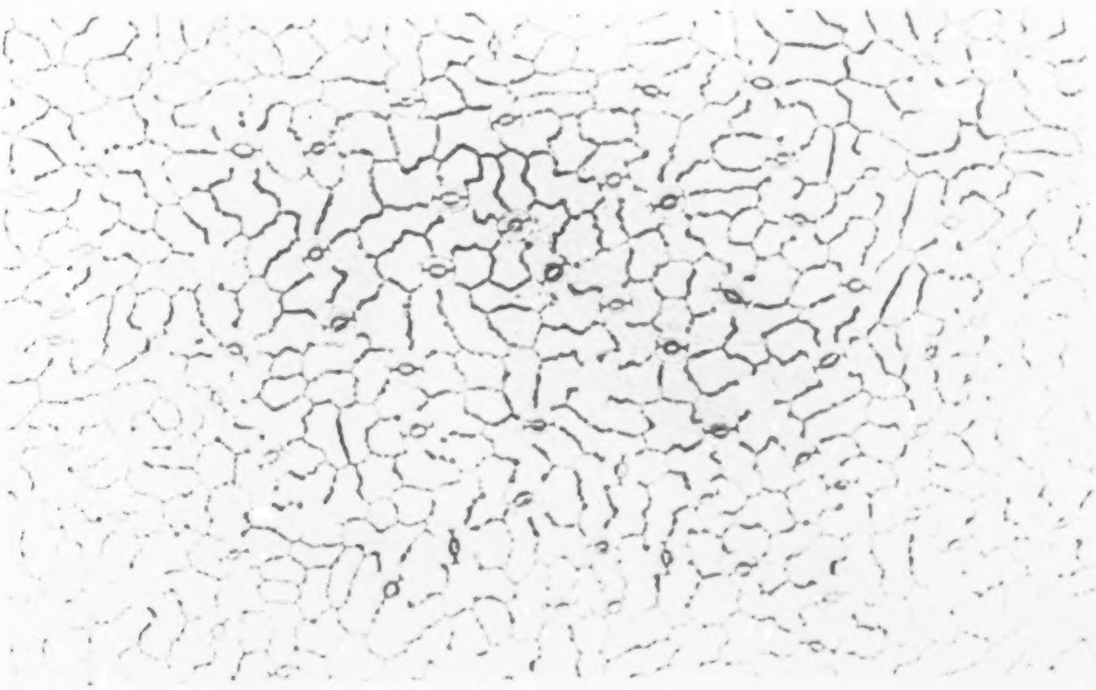
Collinsia parviflora (67)



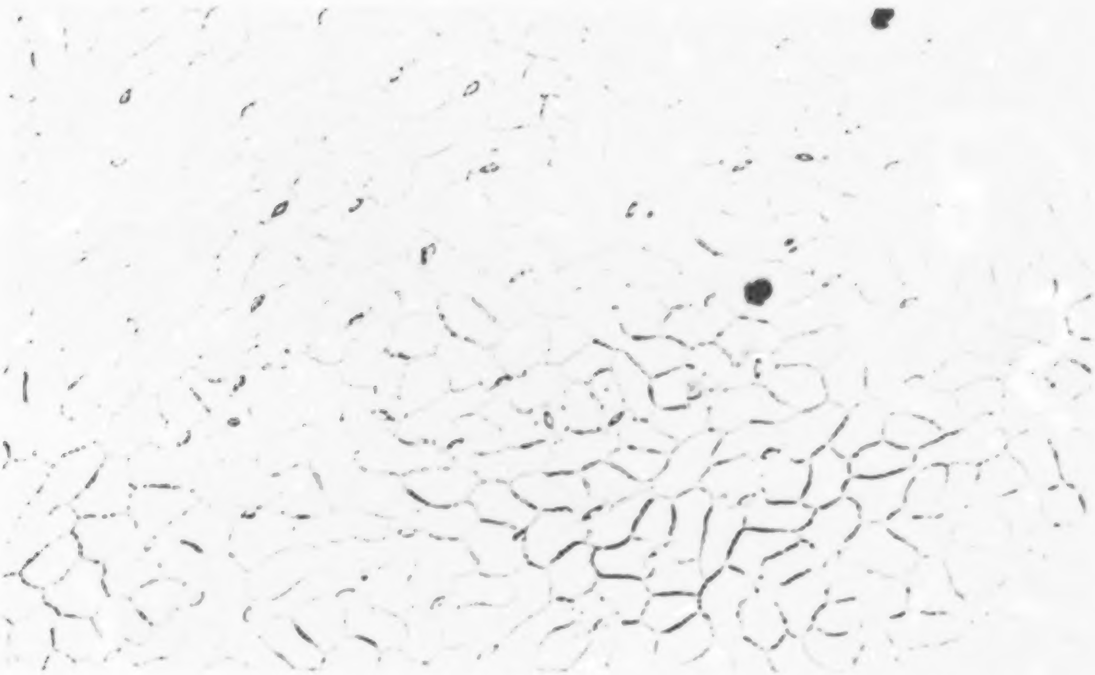
Comandra umbellata (68)



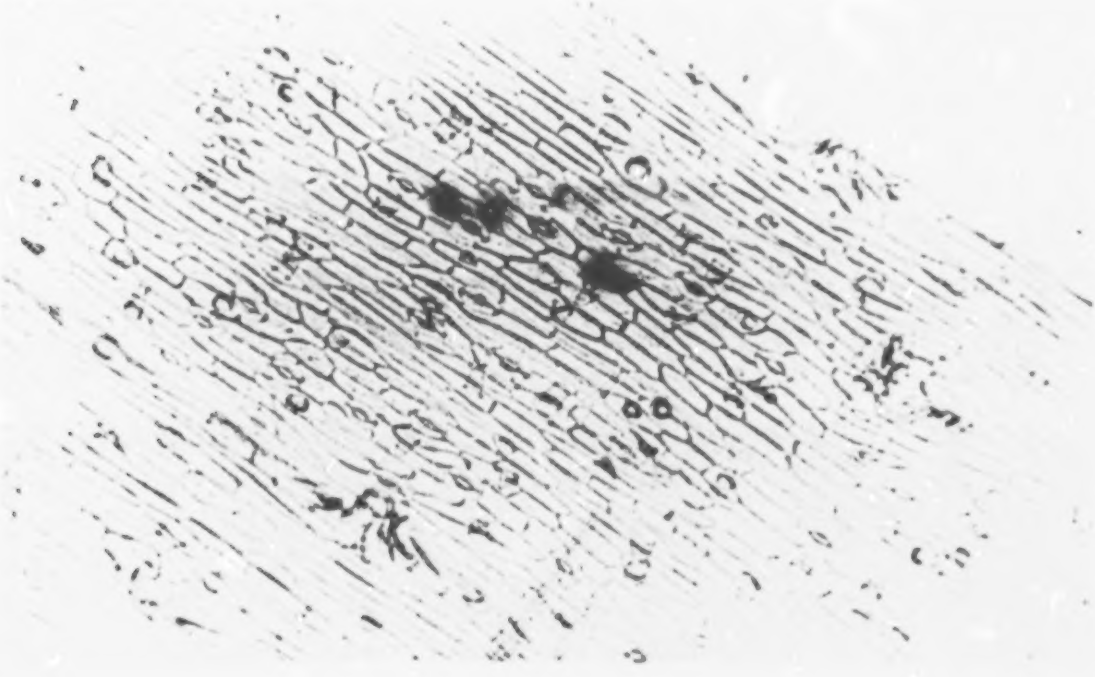
Comandra umbellata (69)



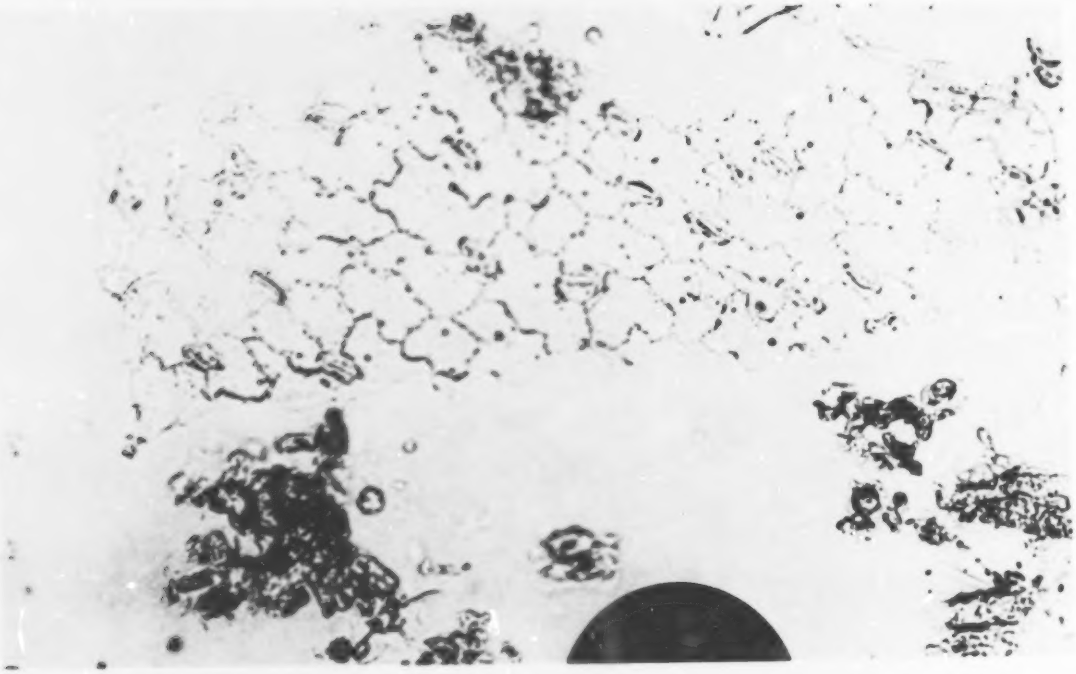
Crepis atrabarba (70)



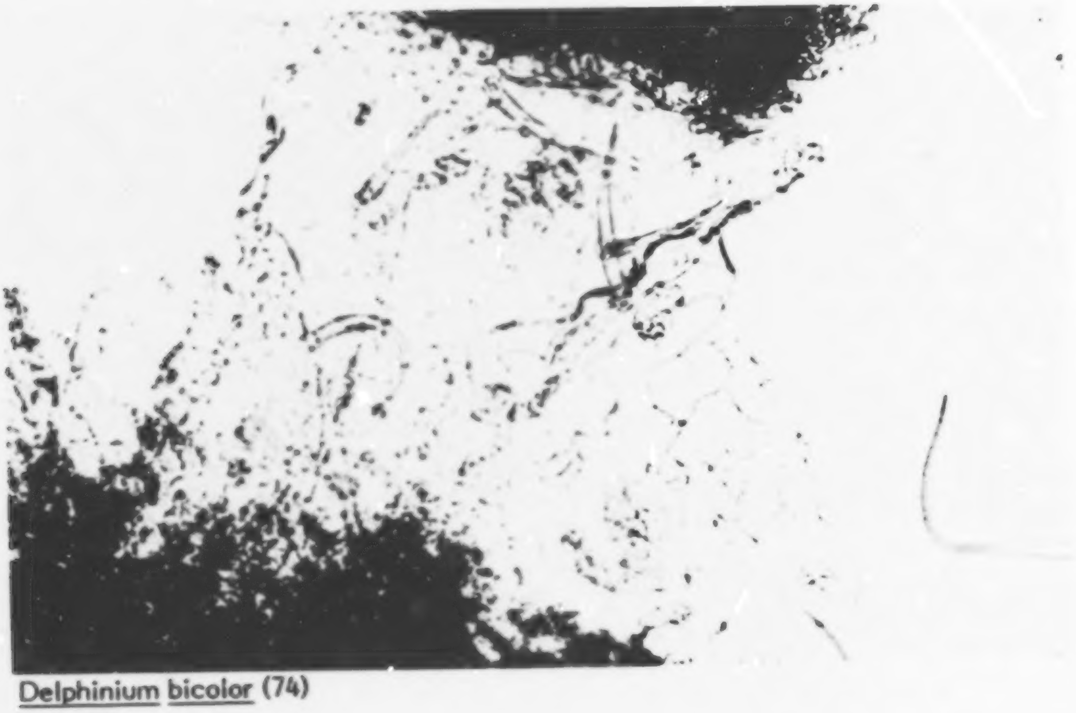
Crepis atrabarba (71)



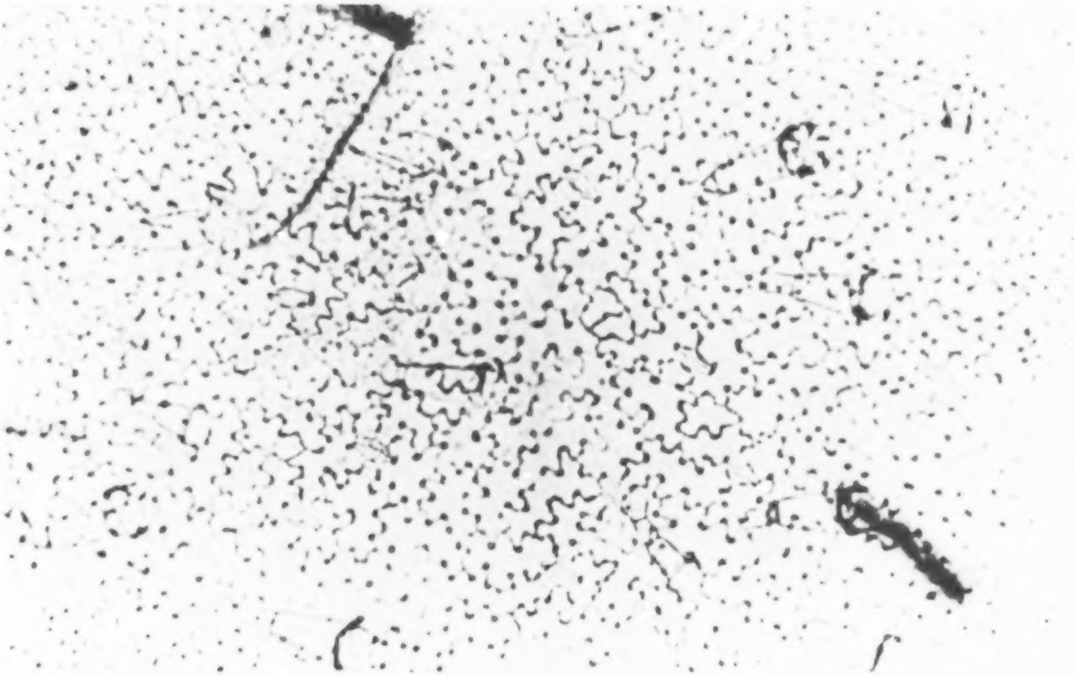
Crepis atrabarba (72)



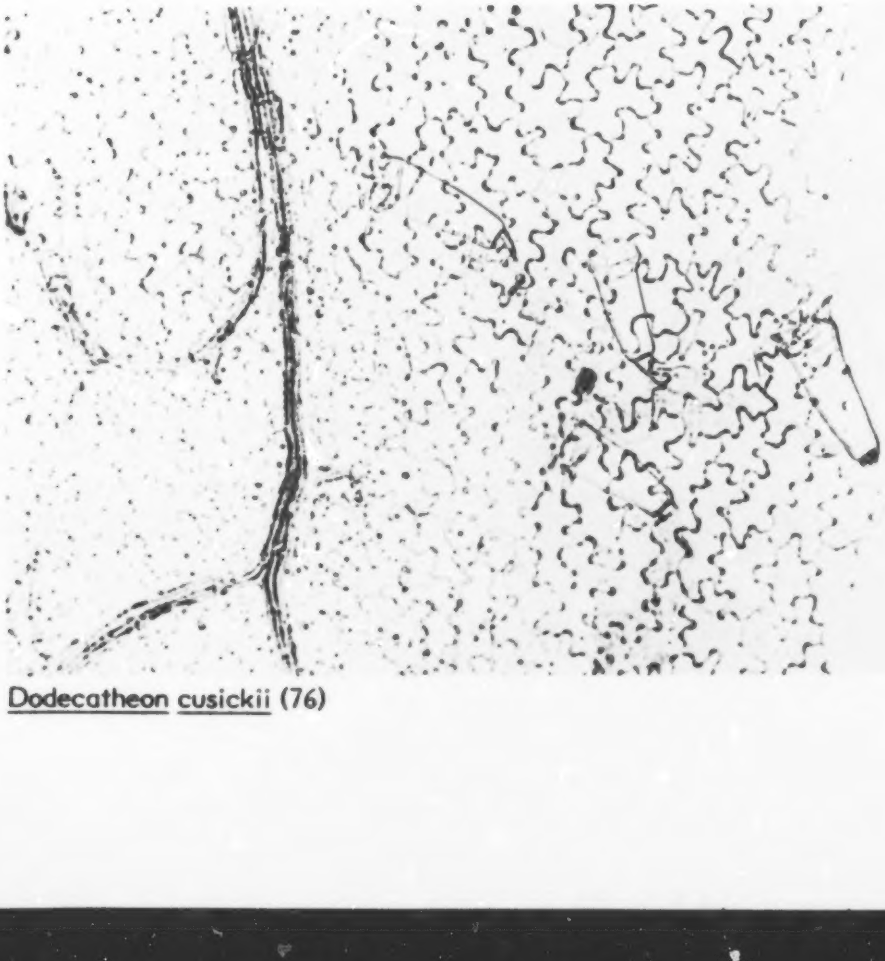
Delphinium bicolor (73)



Delphinium bicolor (74)

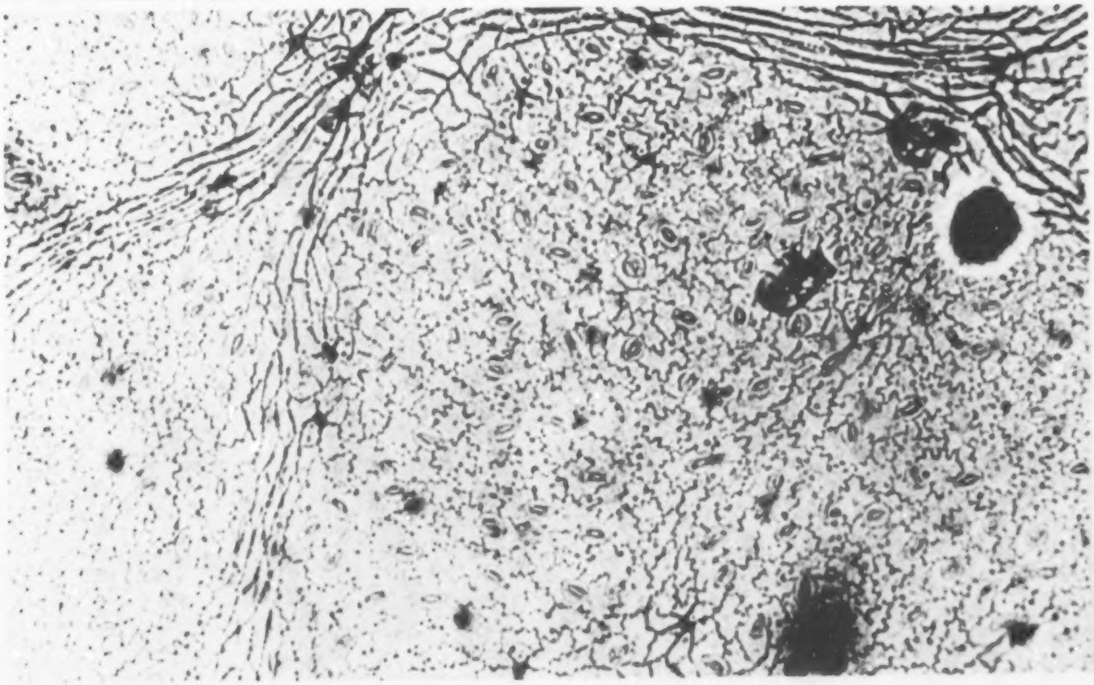


Dodecatheon cusickii (75)

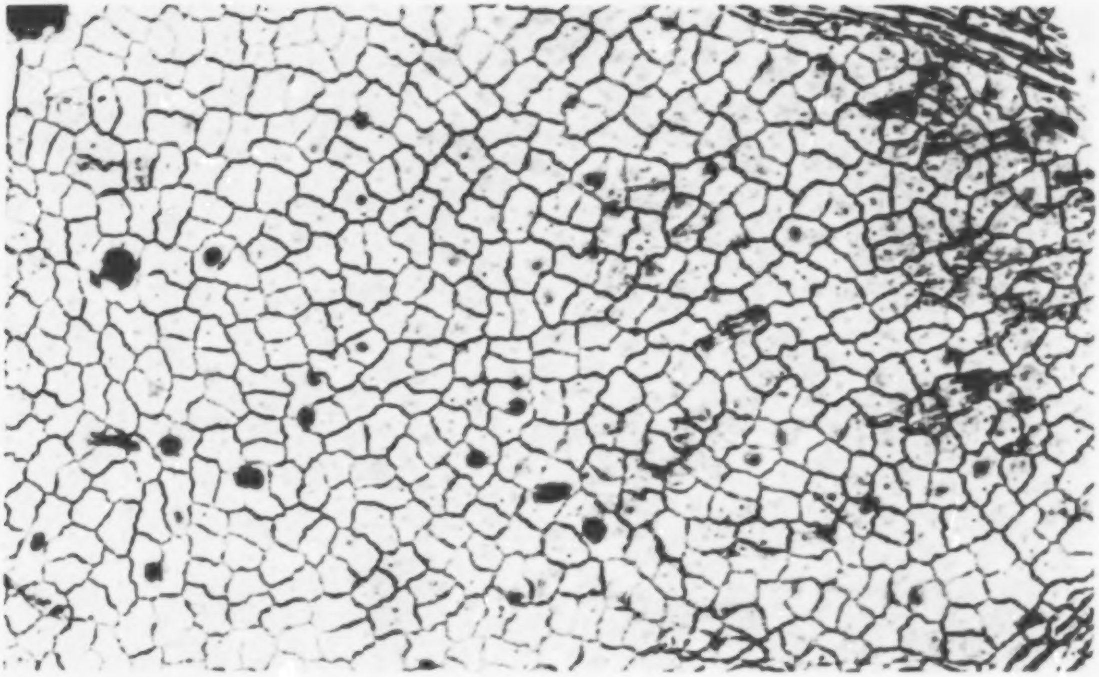


Dodecatheon cusickii (76)

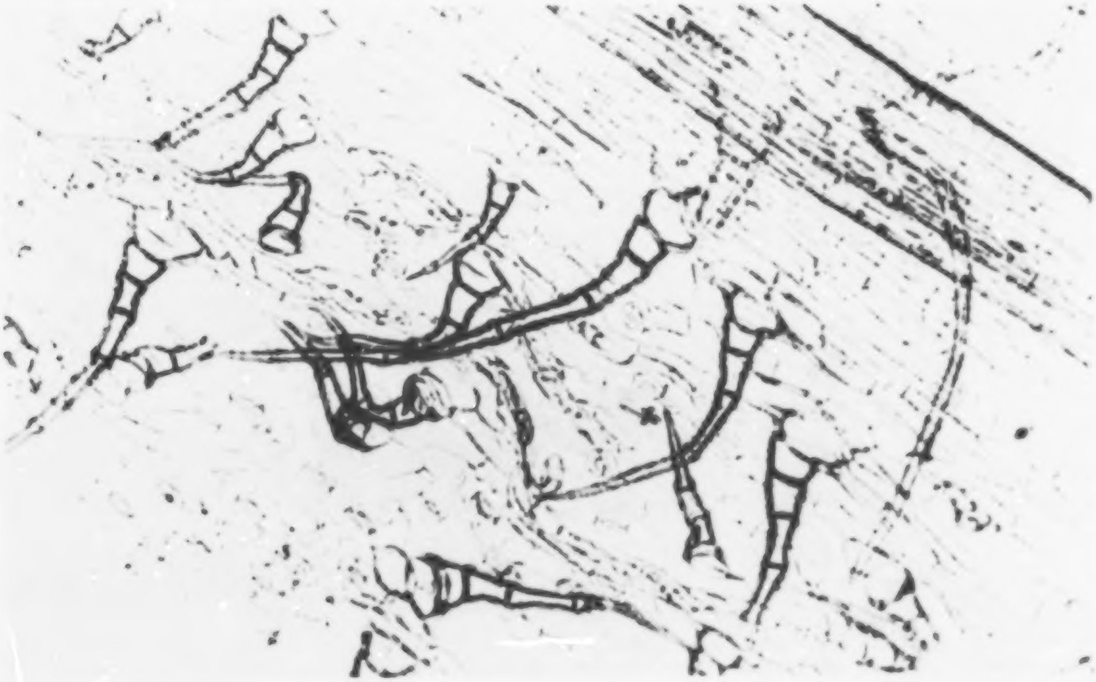
Dodecatheon cusickii (77)



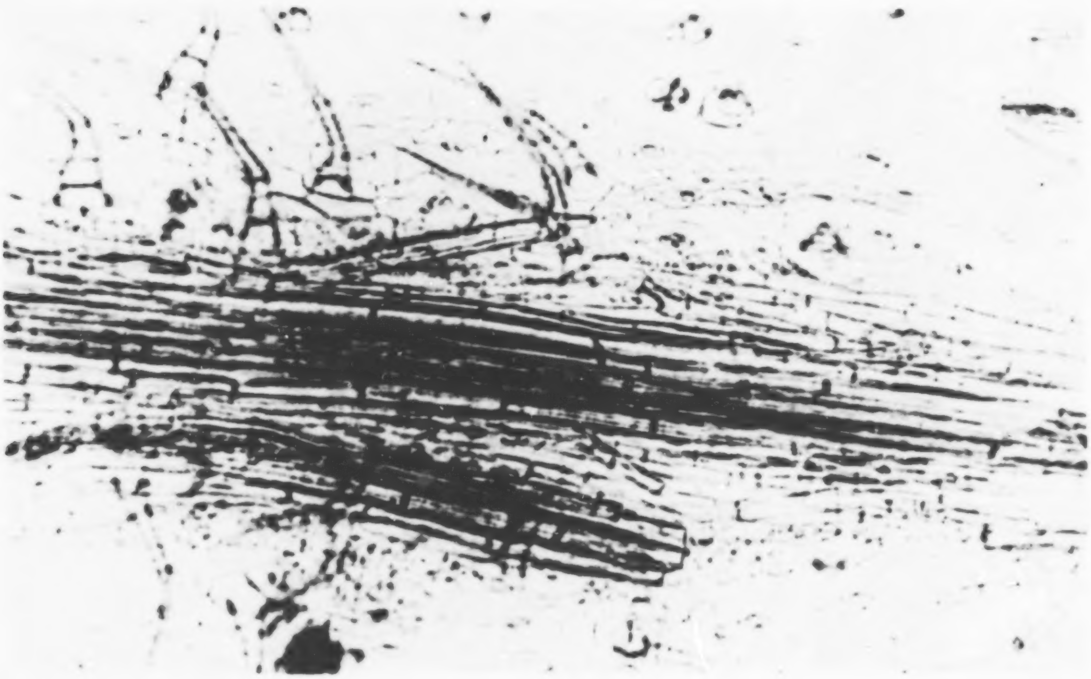
Epilobium angustifolium (78)



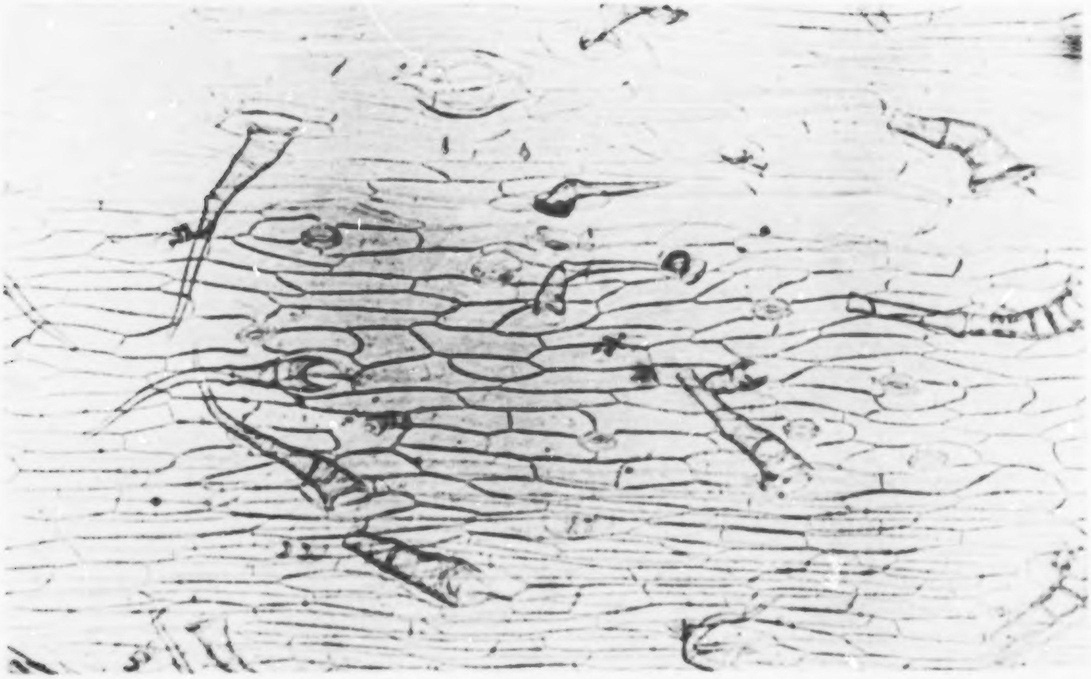
Epilobium angustifolium (79)



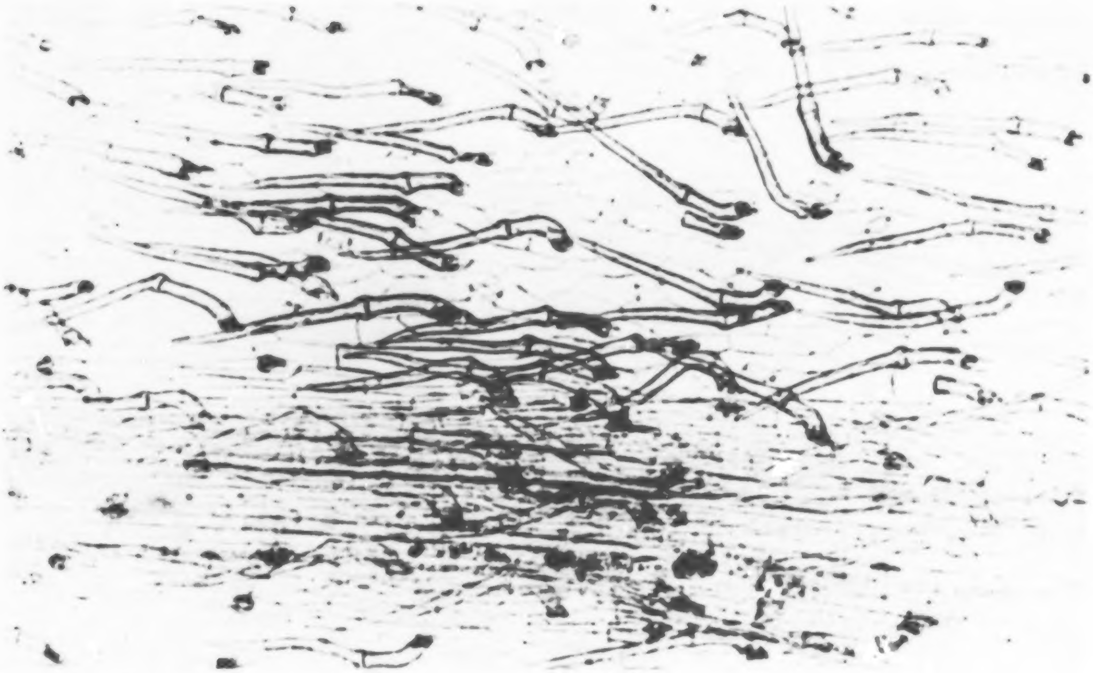
Erigeron corymbosus (80)



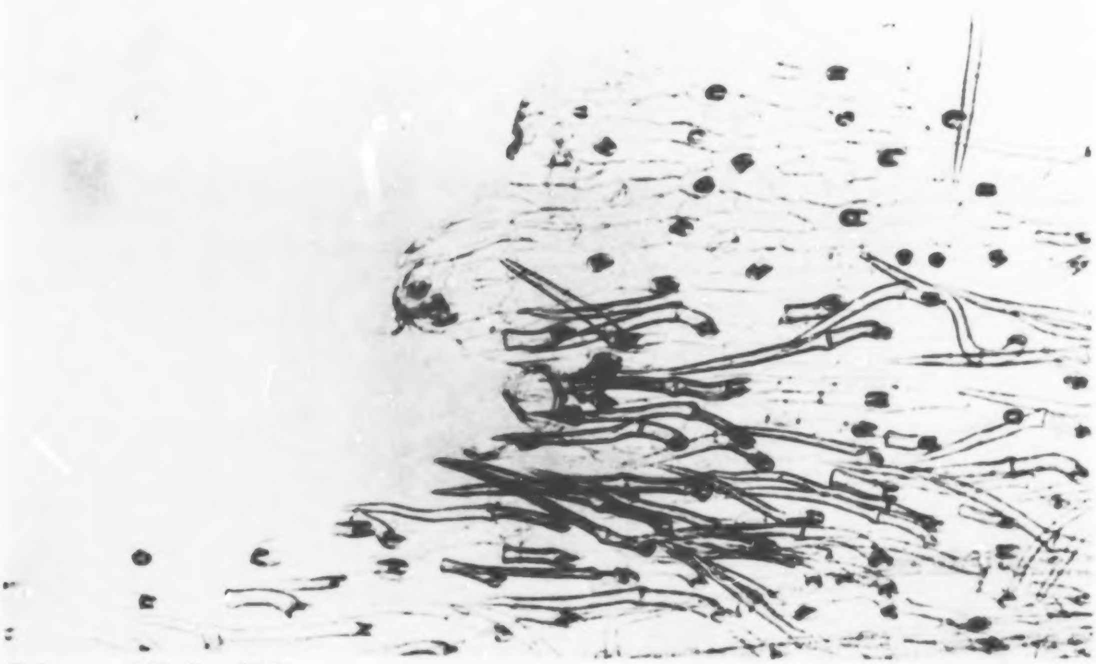
Erigeron corymbosus (81)



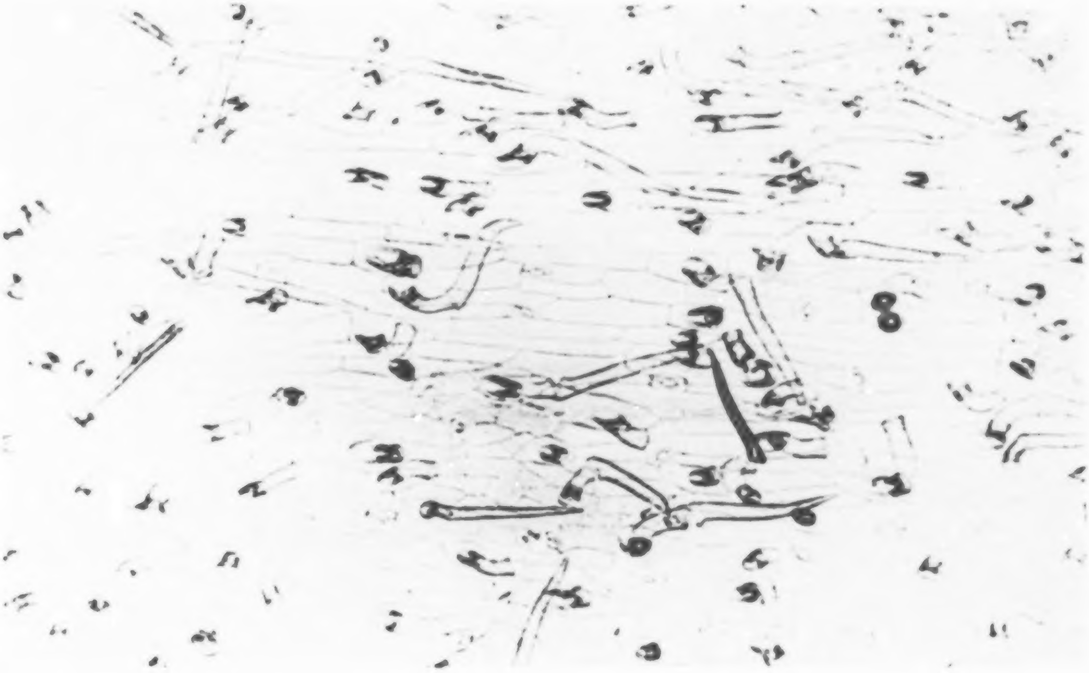
Erigeron corymbosus (82)



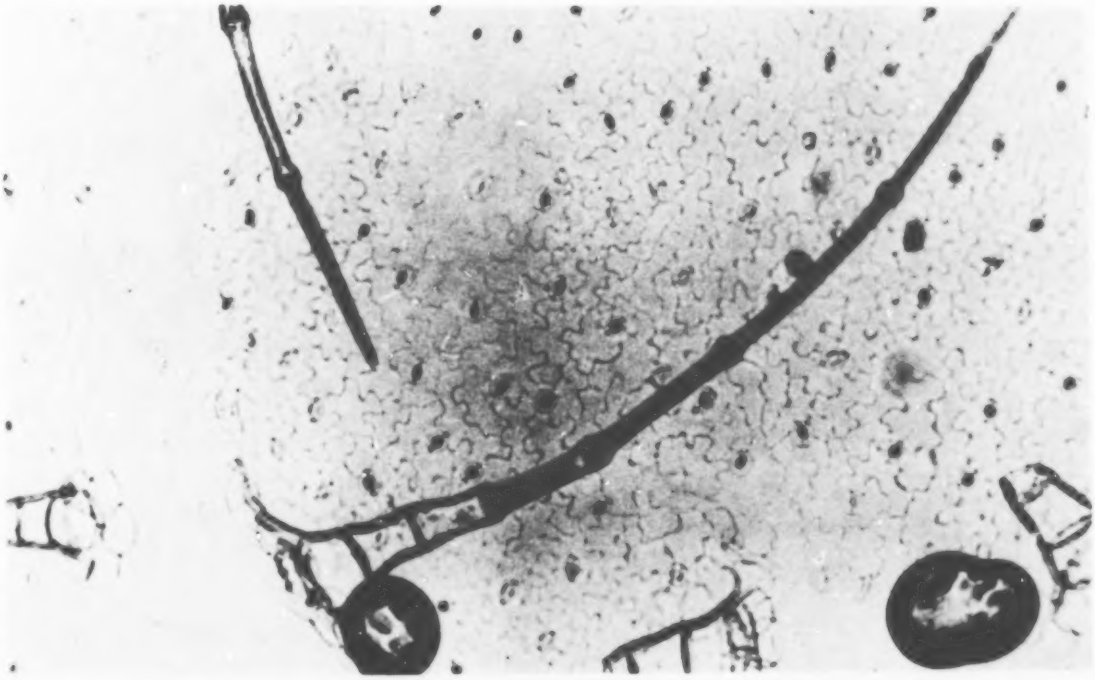
Erigeron *filifolius* (83)



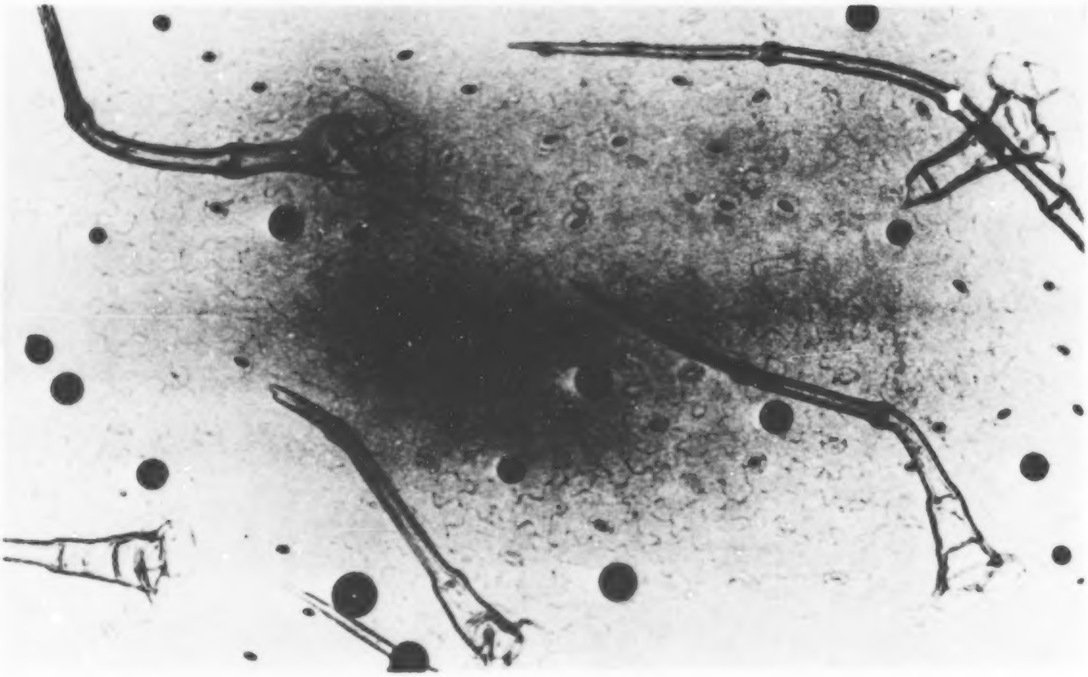
Erigeron *filifolius* (84)



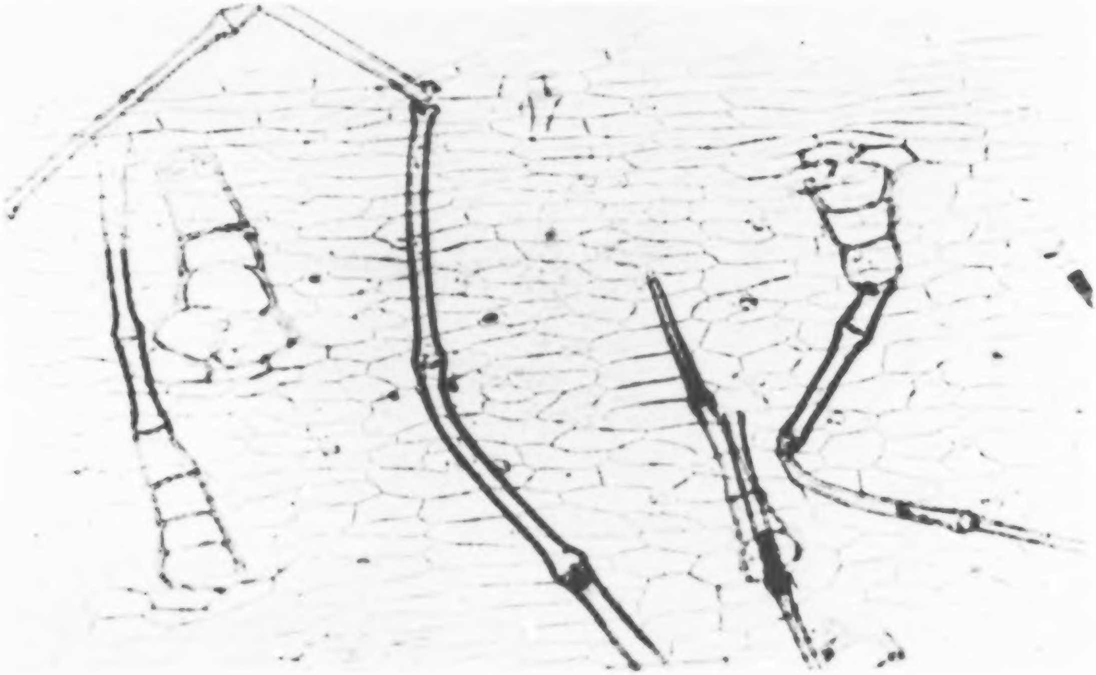
Erigeron filifolius (85)



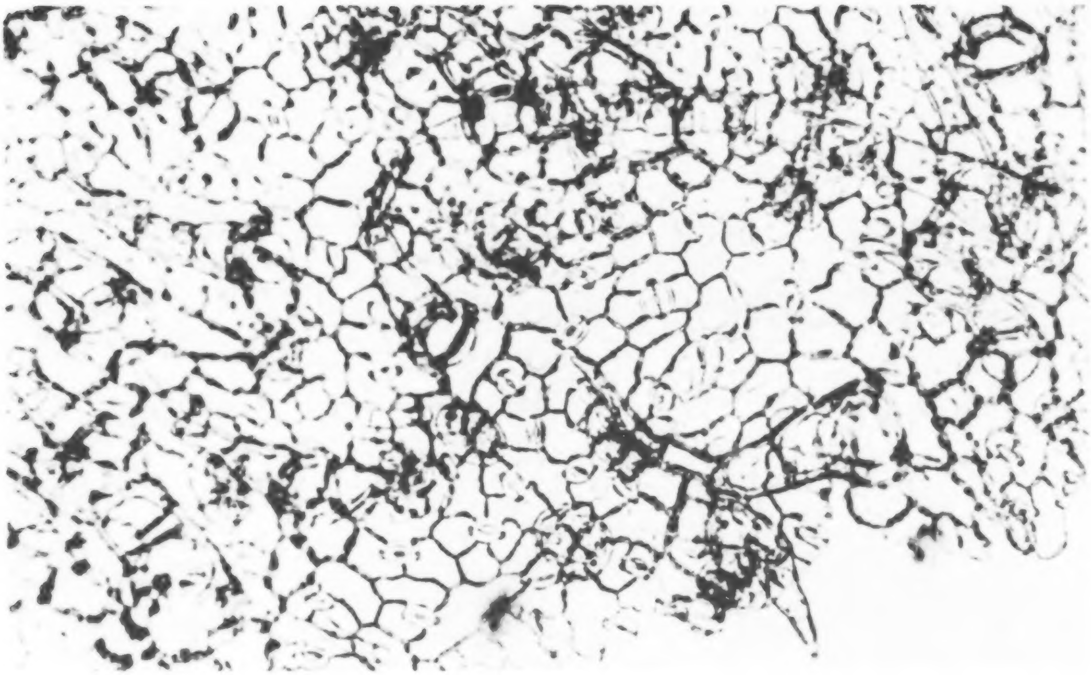
Erigeron pumilus (86)



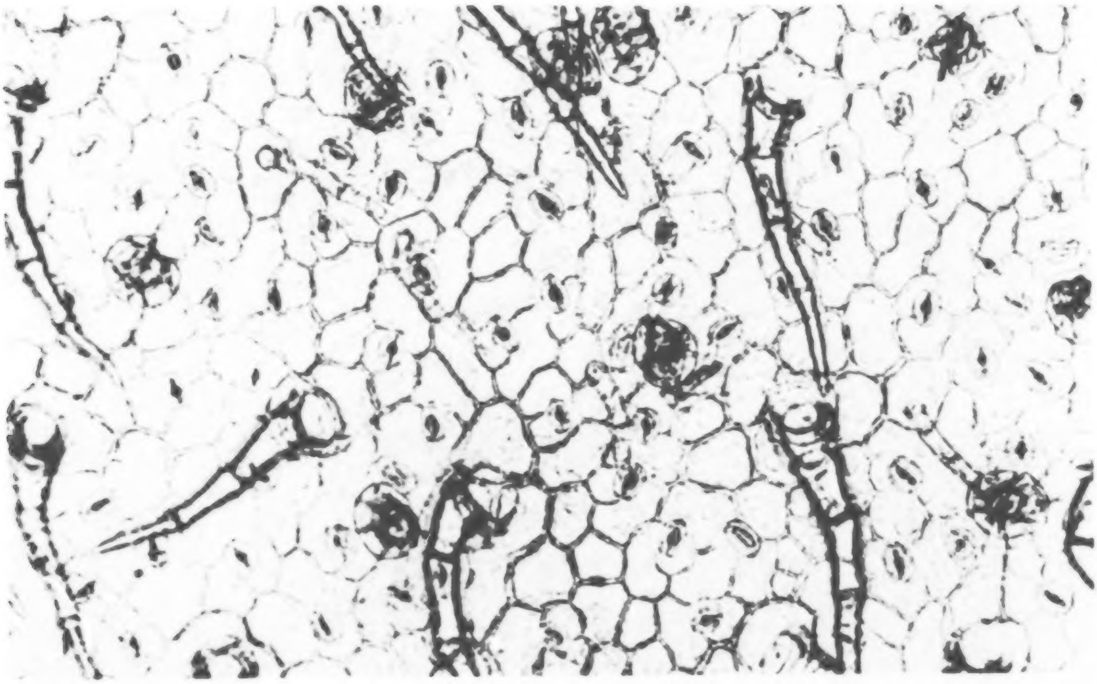
Erigeron pumilus (87)



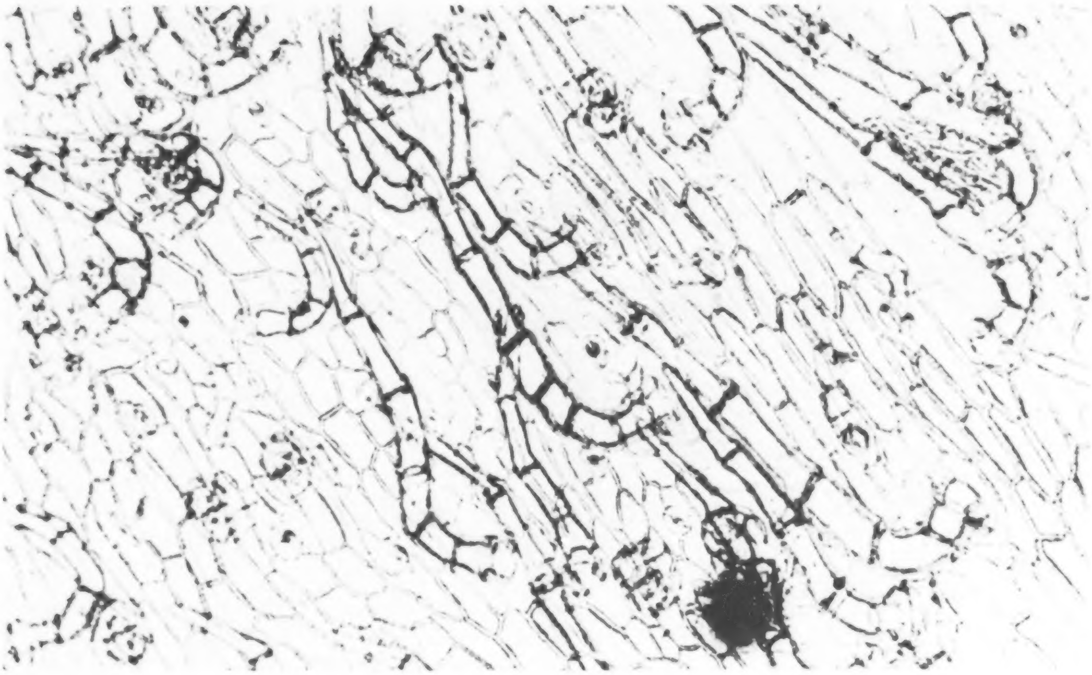
Erigeron pumilus (88)



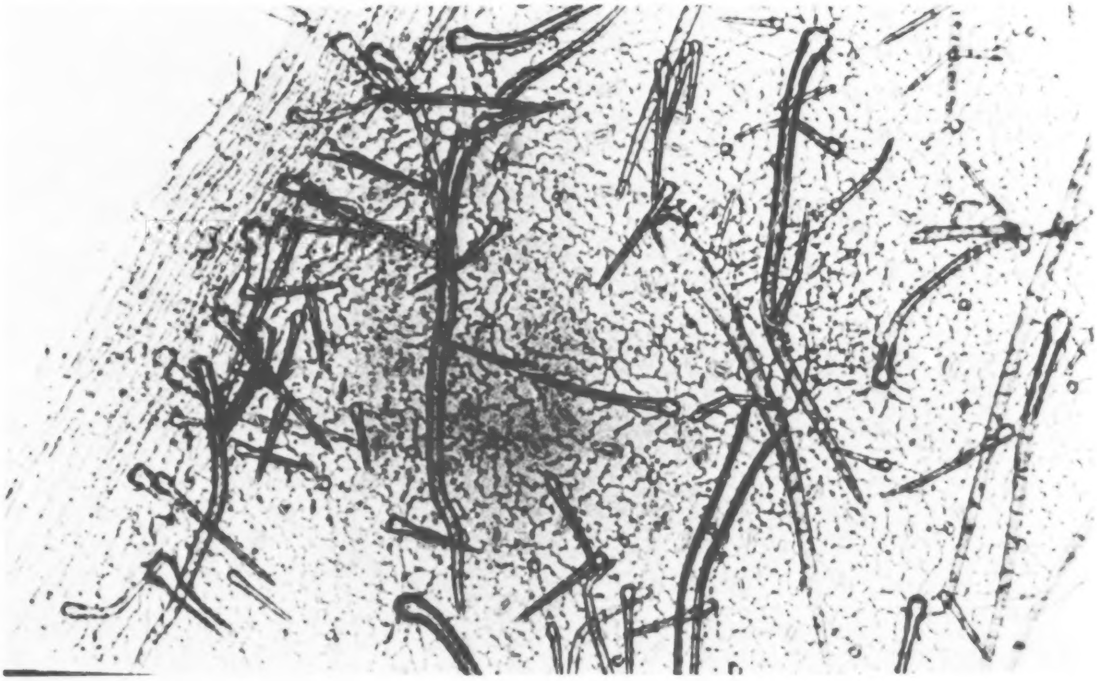
Gaillardia aristata (89)



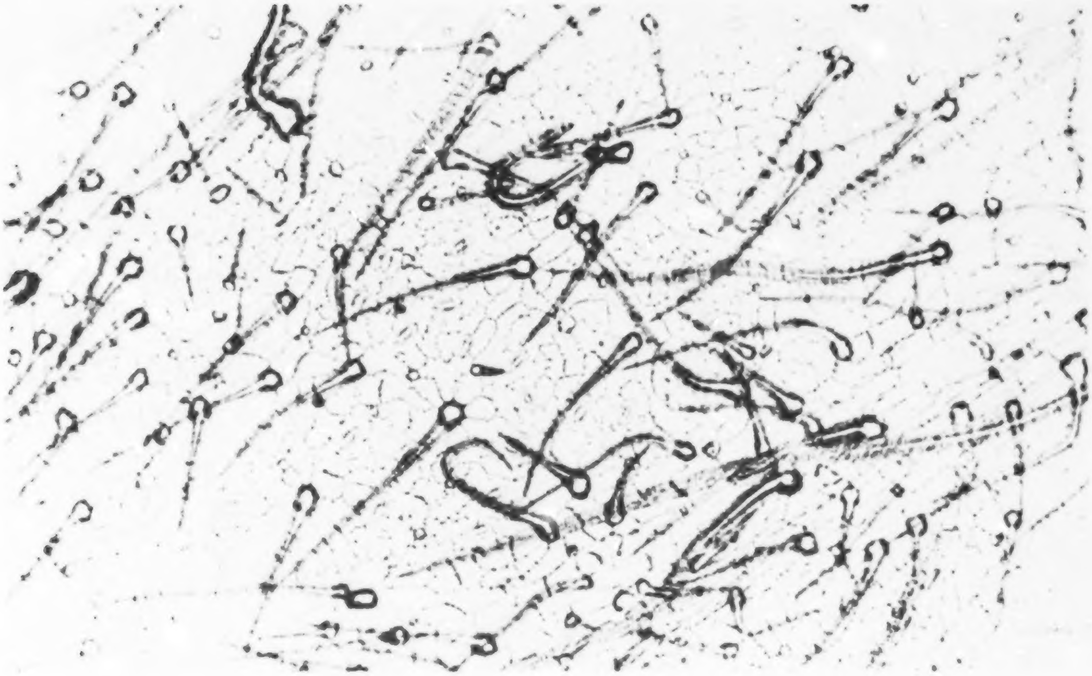
Gaillardia aristata (90)



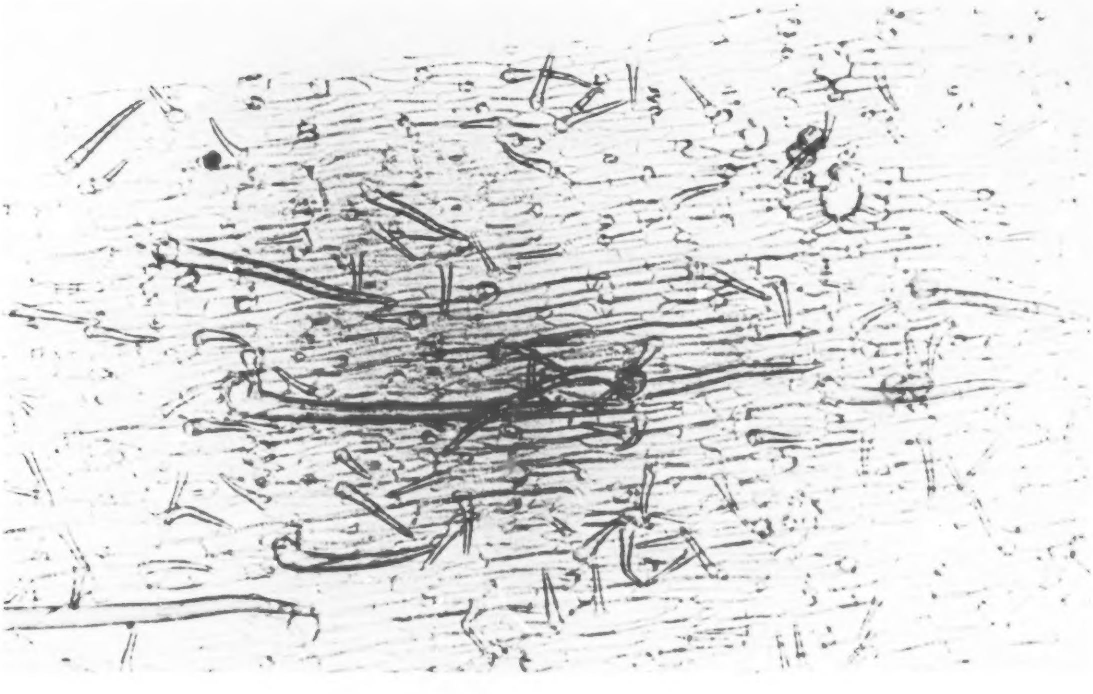
Gaillardia aristata (91)



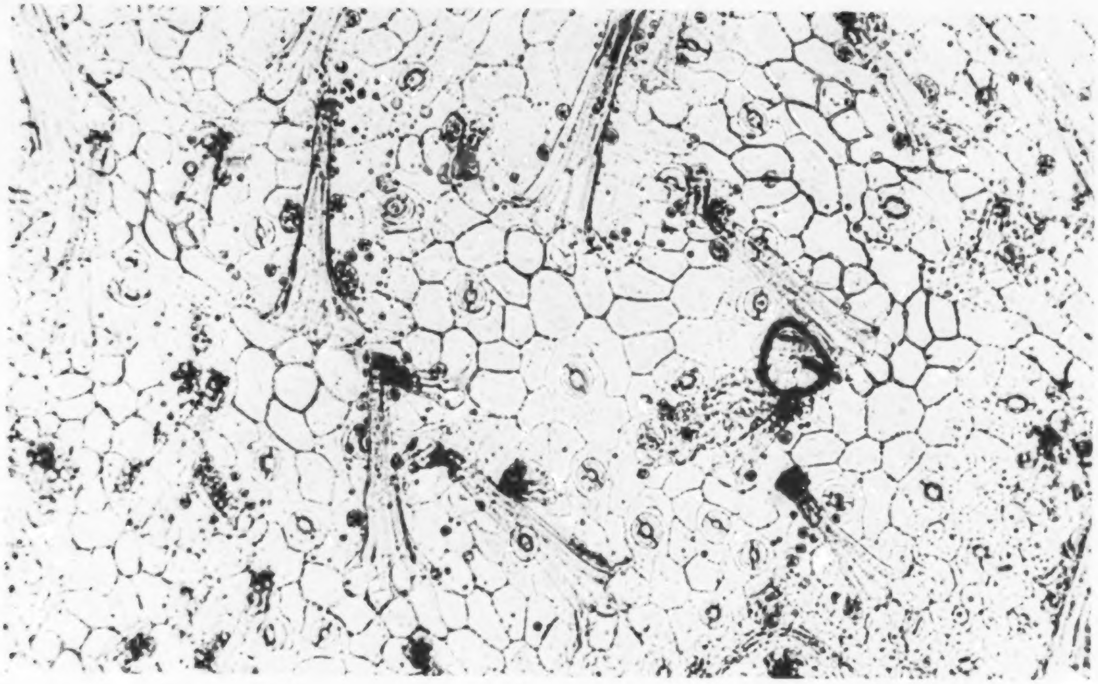
Geum triflorum (92)



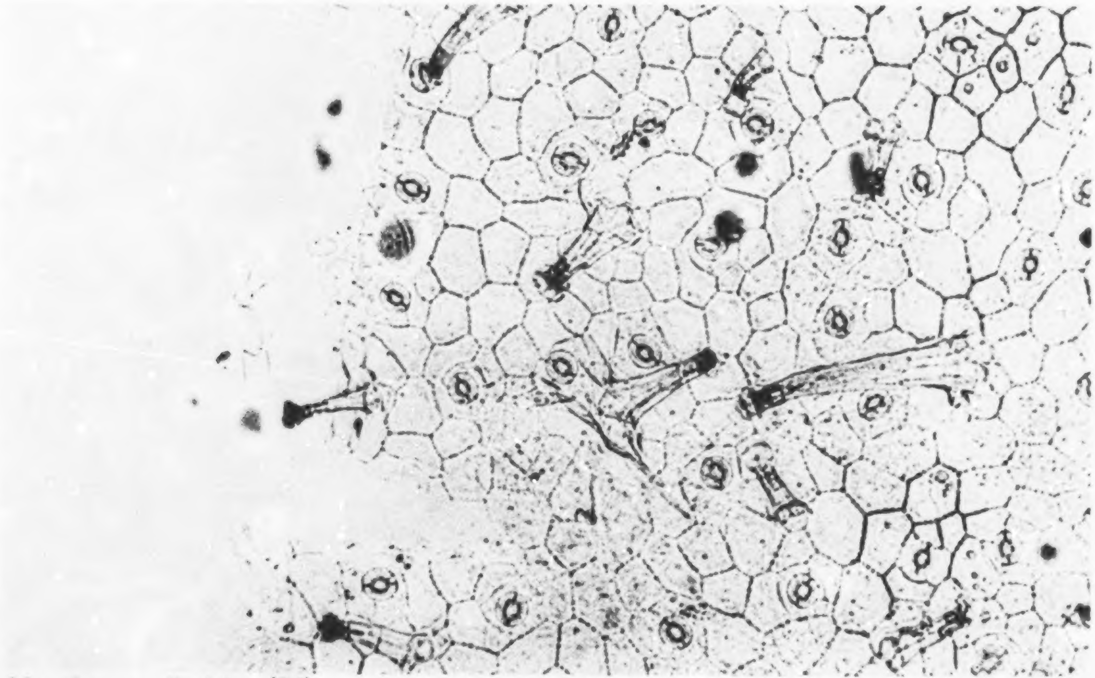
Geum triflorum (93)



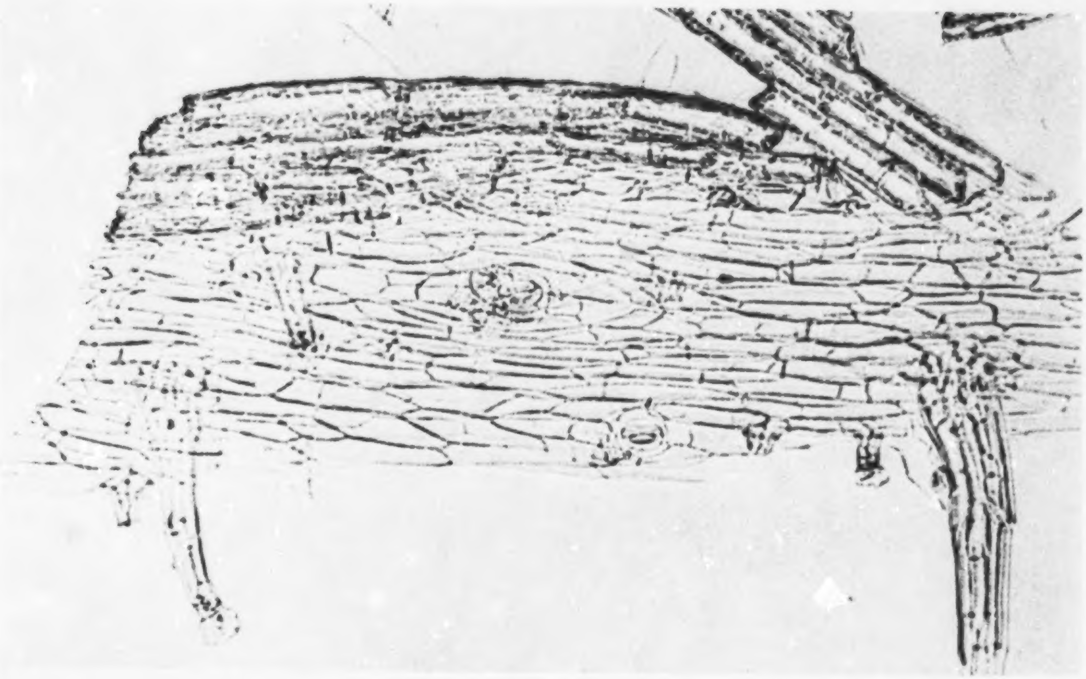
Geum triflorum (94)



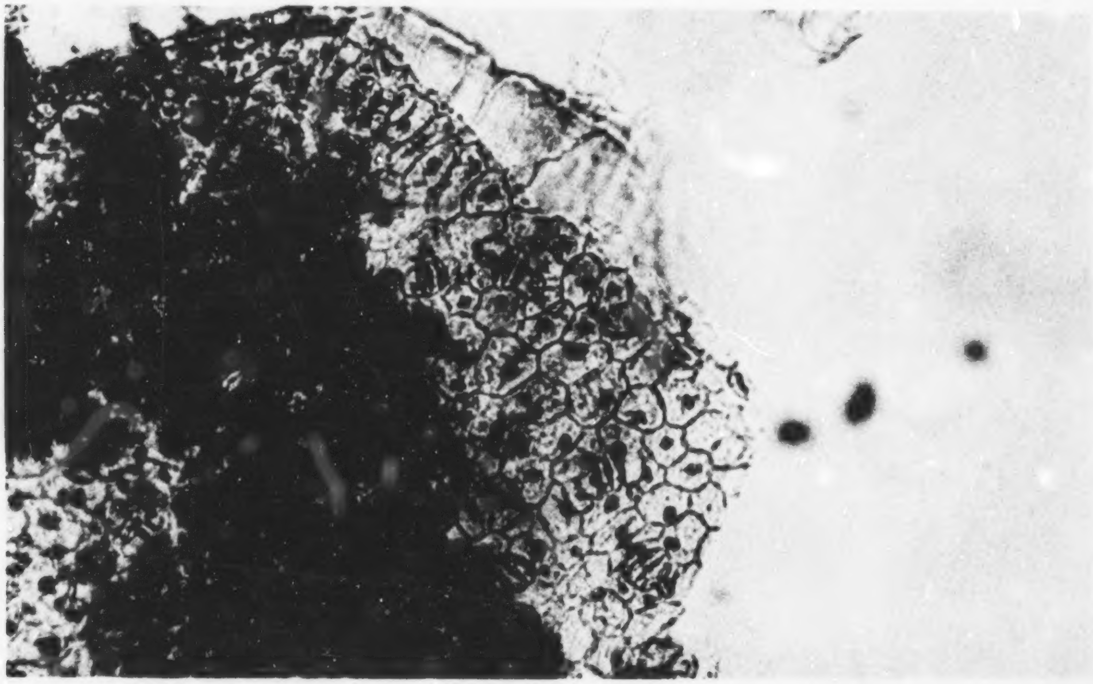
Heuchera cylindrica (95)



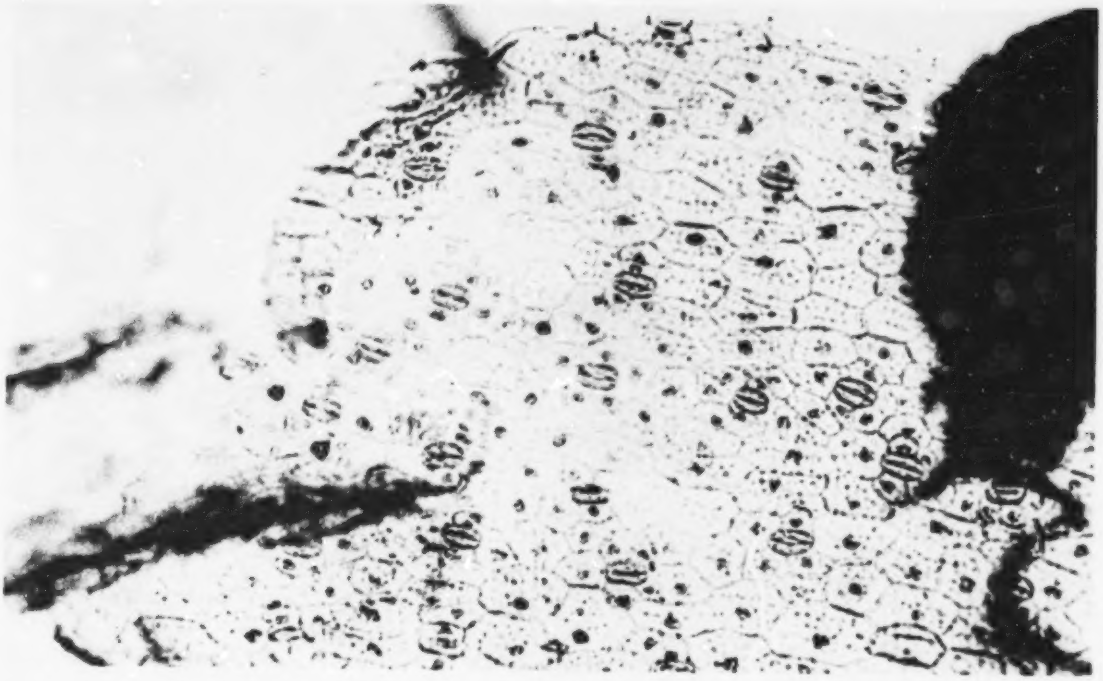
Heuchera cylindrica (96)



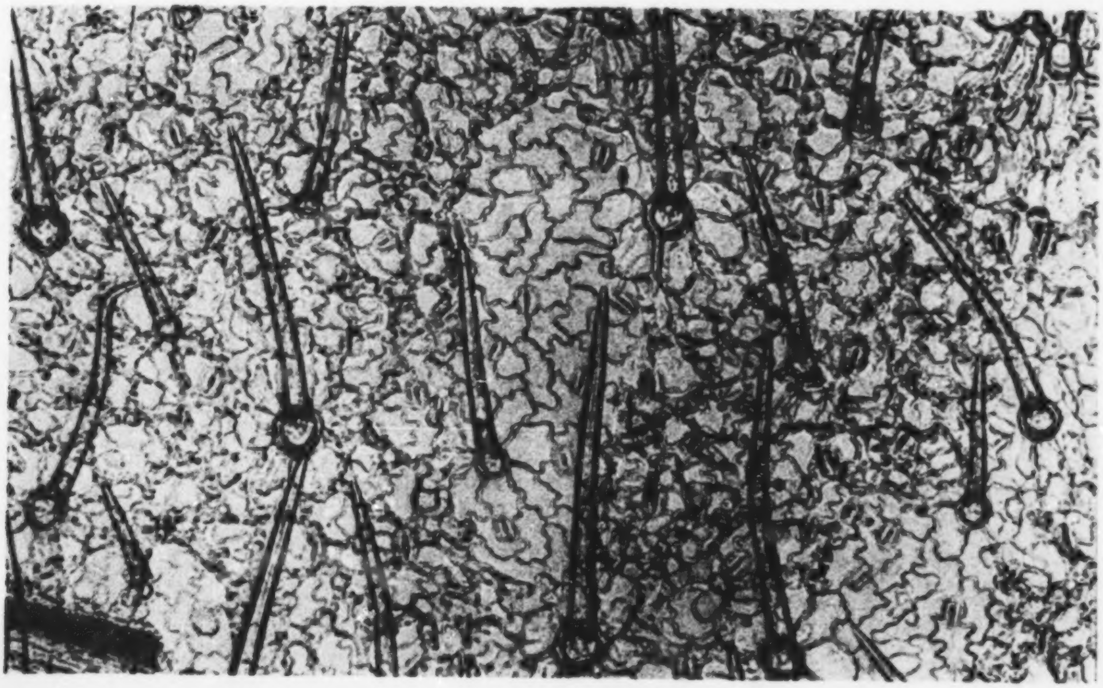
Heuchera cylindrica (97)



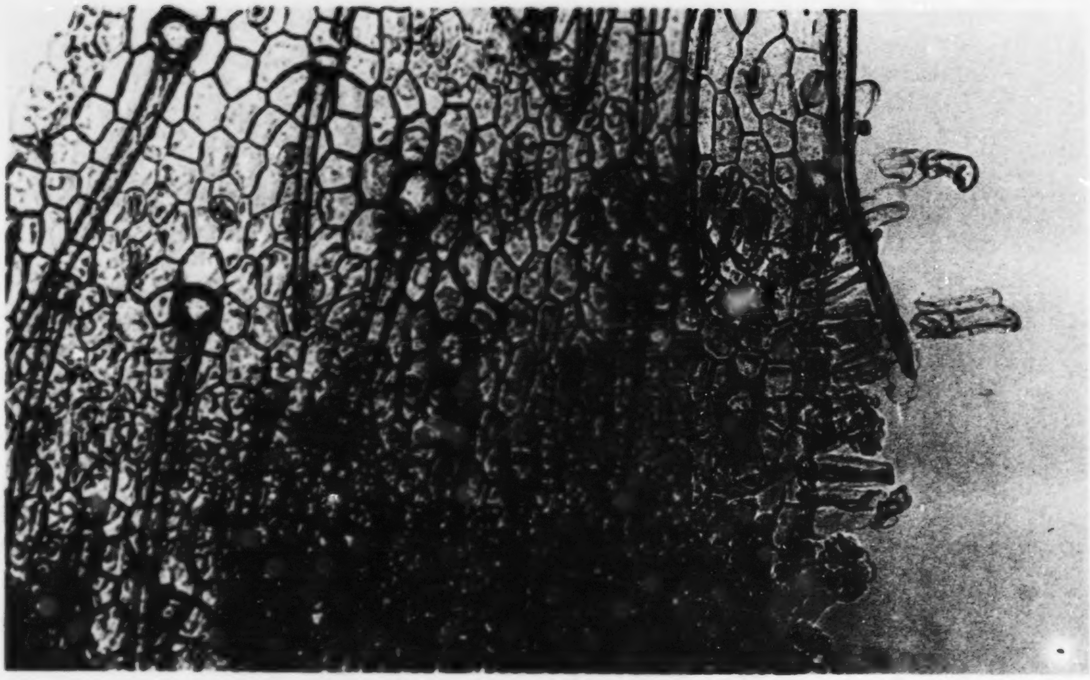
Lewisia rediviva (98)



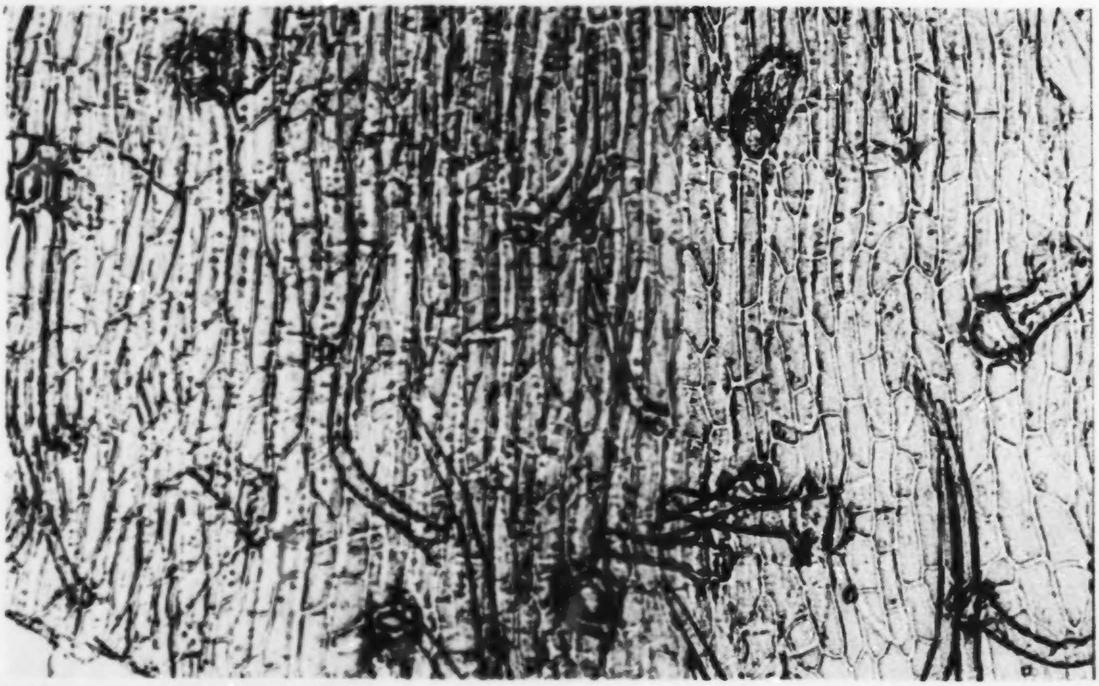
Lewisia rediviva (99)



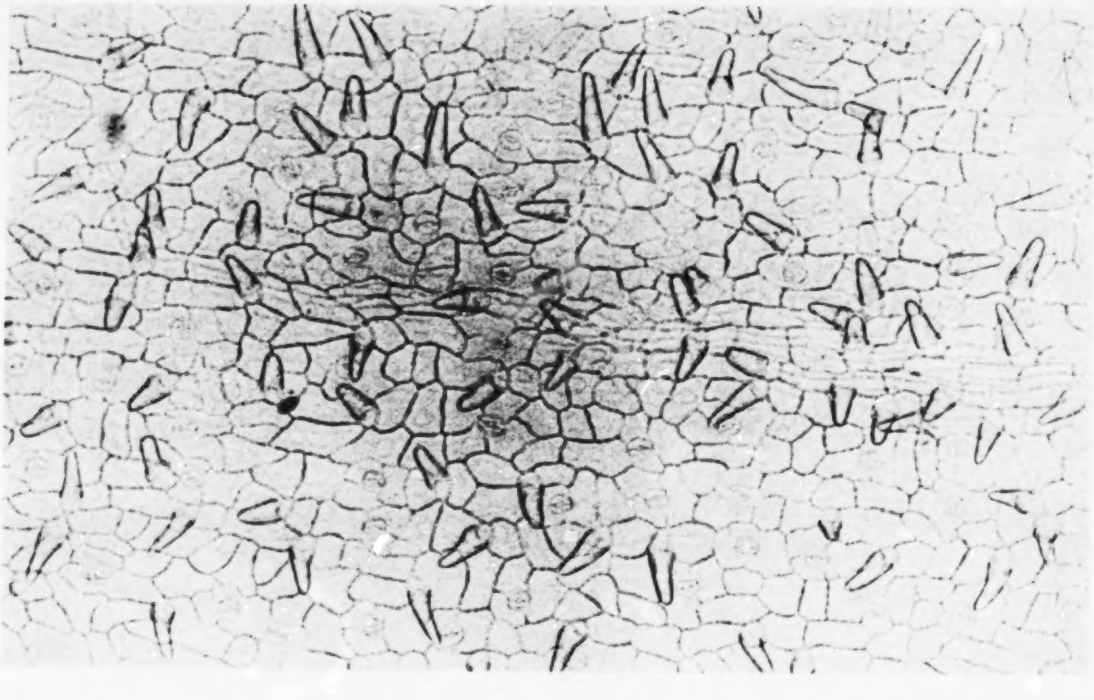
Lithospermum ruderale (100)



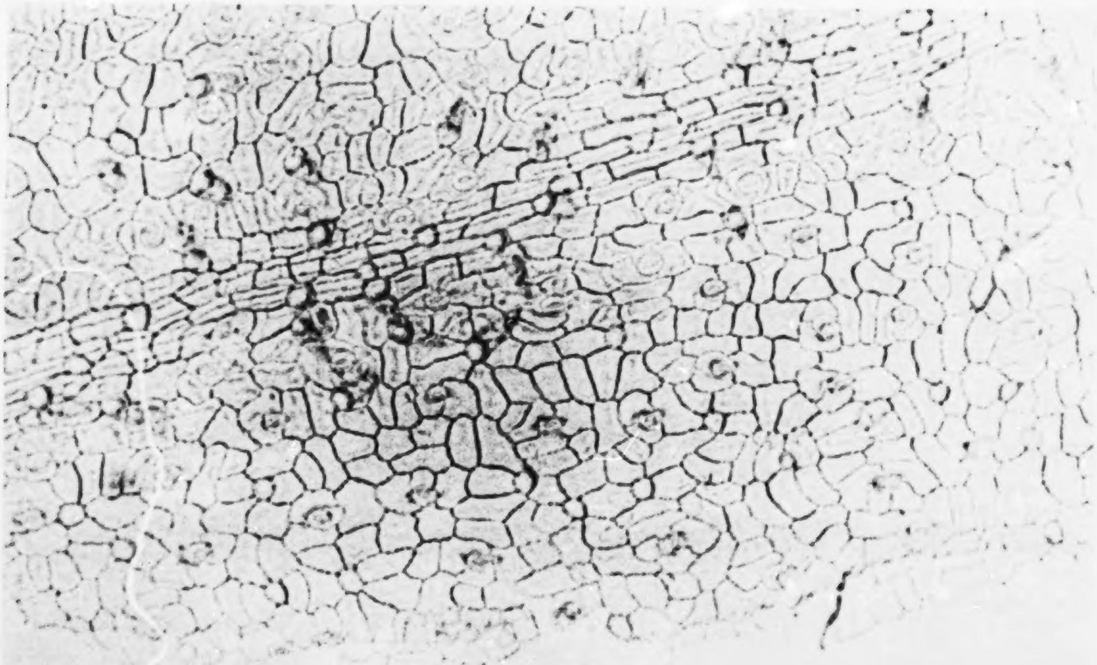
Lithospermum ruderale (101)



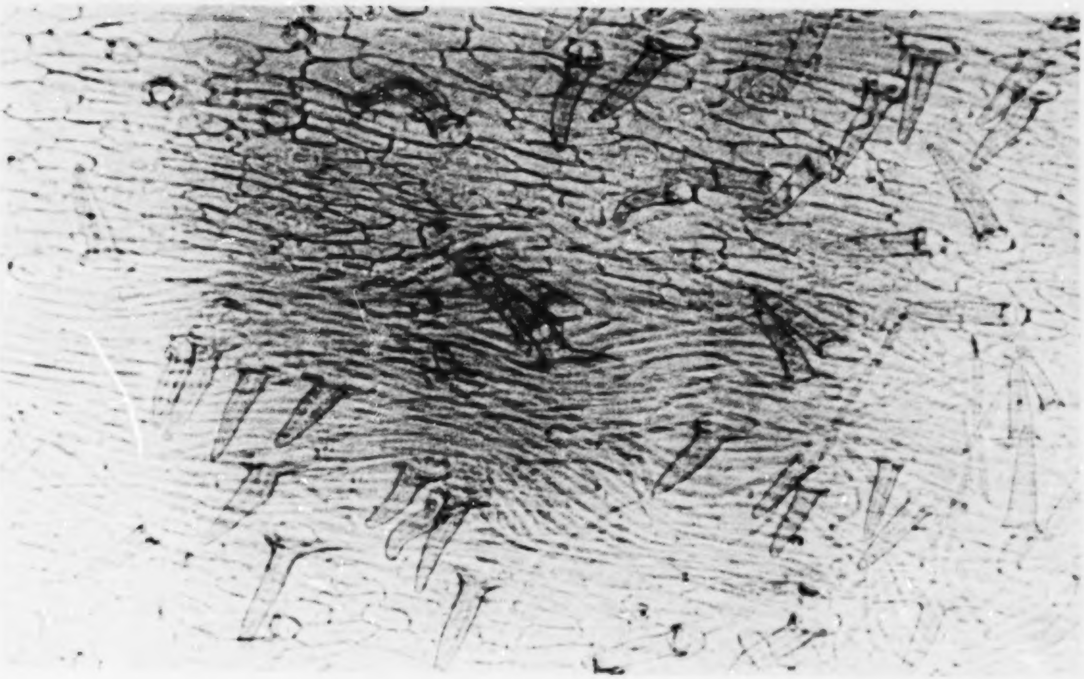
Lithospermum ruderale (102)



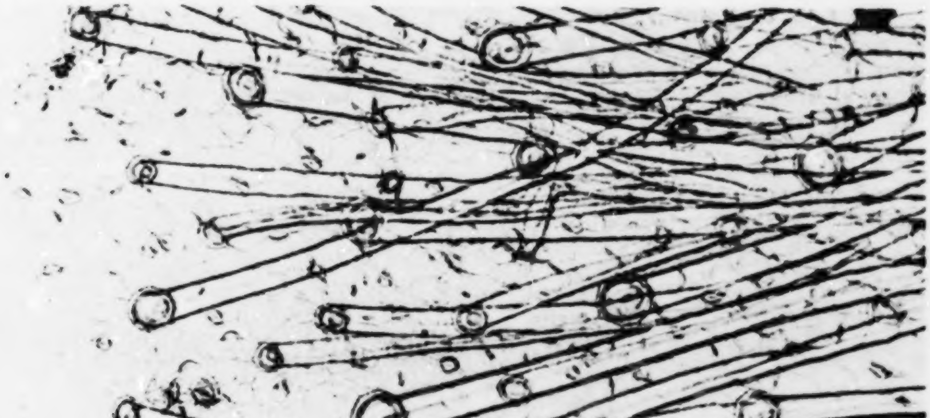
Lomatium triternatum (103)



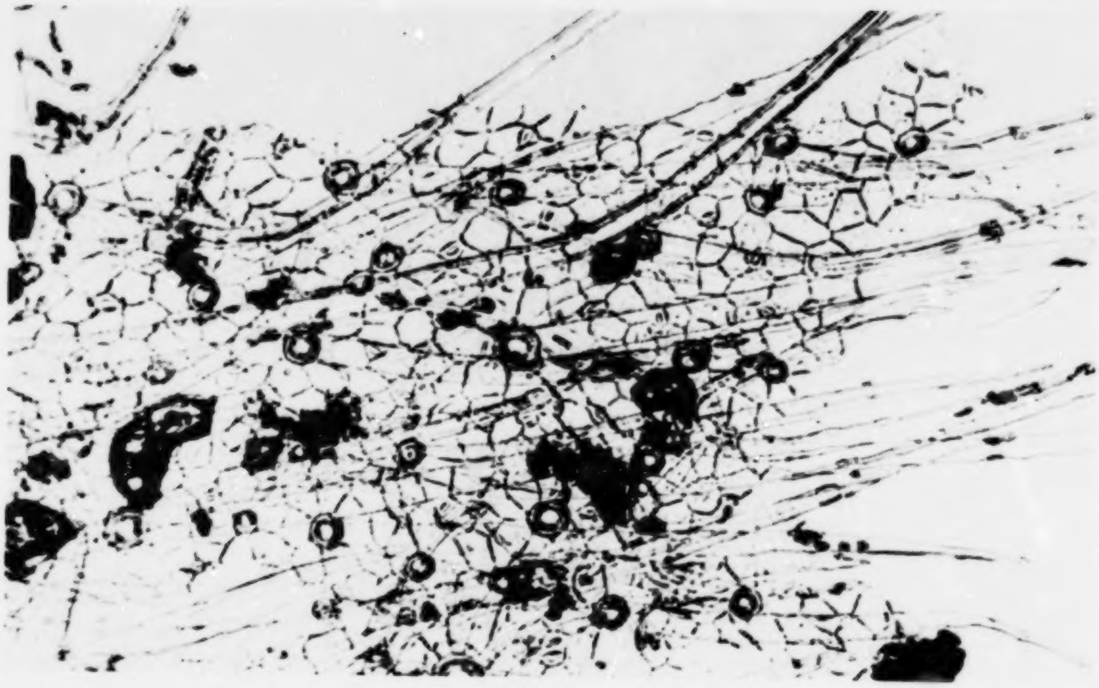
Lomatium triternatum (104)



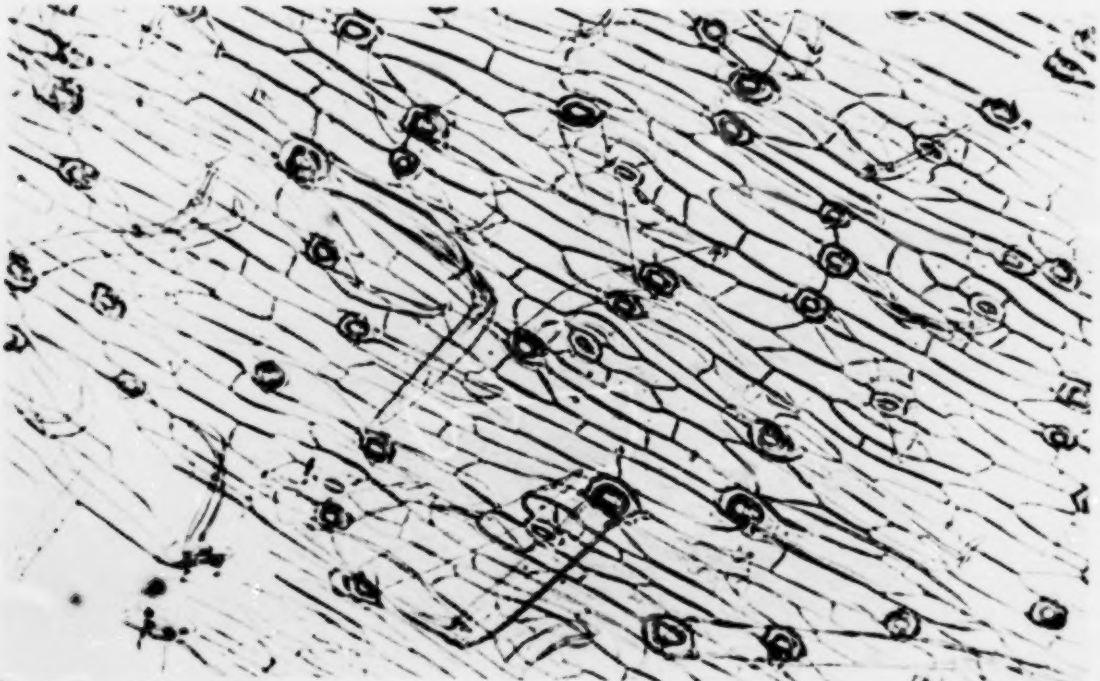
Lomatium triternatum (105)



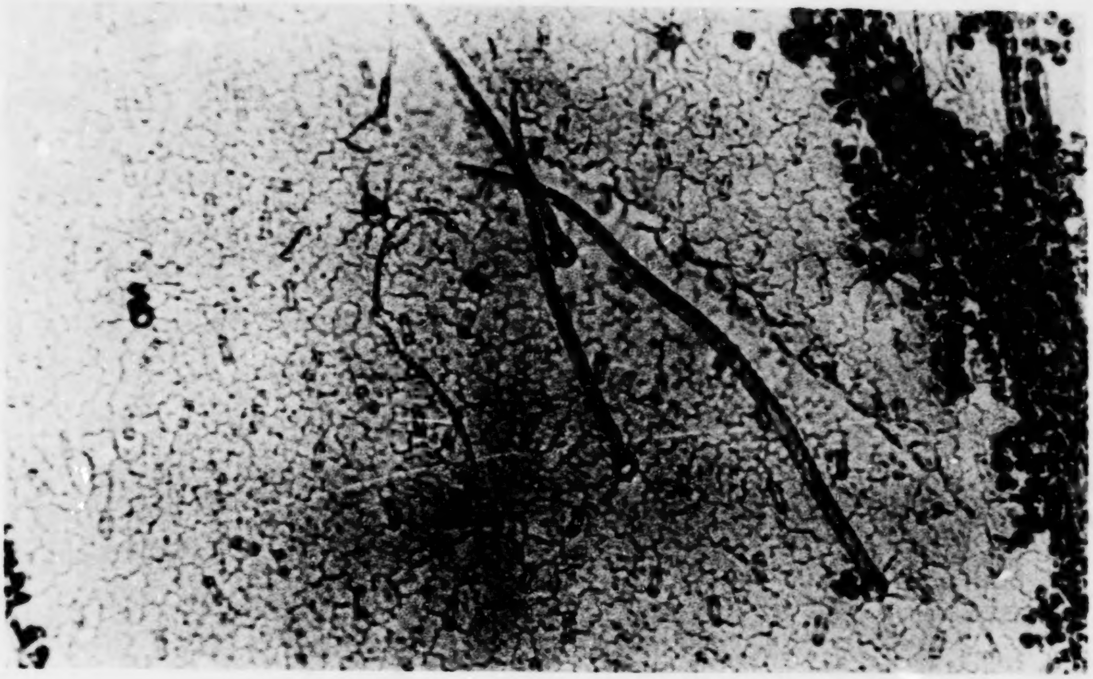
Lupinus sericeus (106)



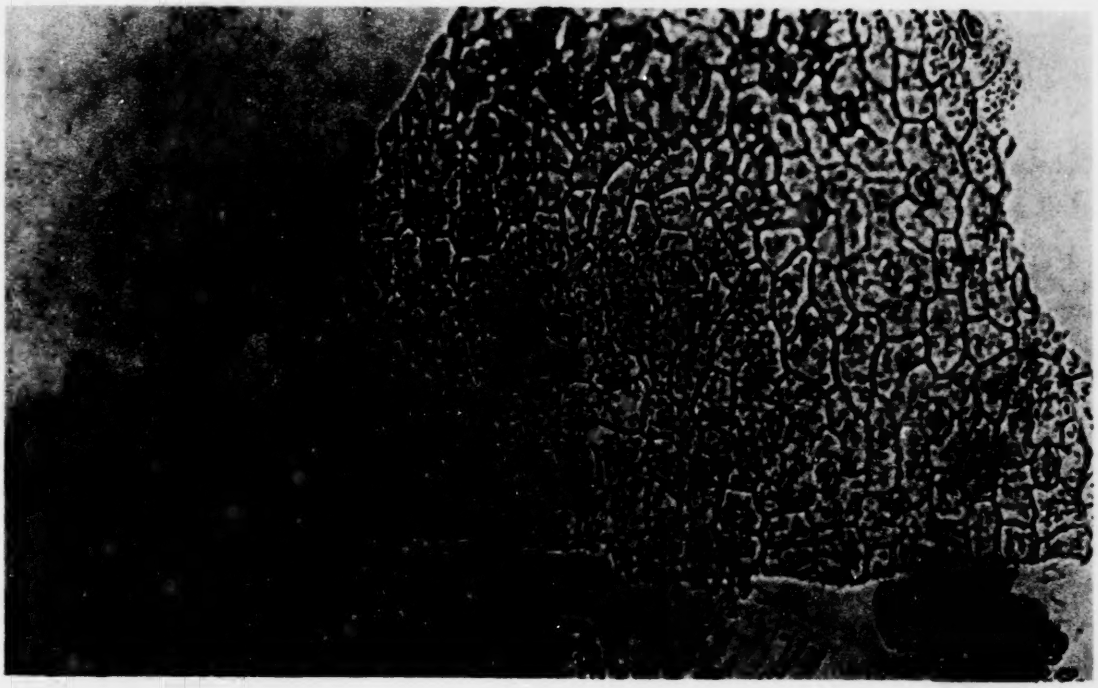
Lupinus sericeus (107)



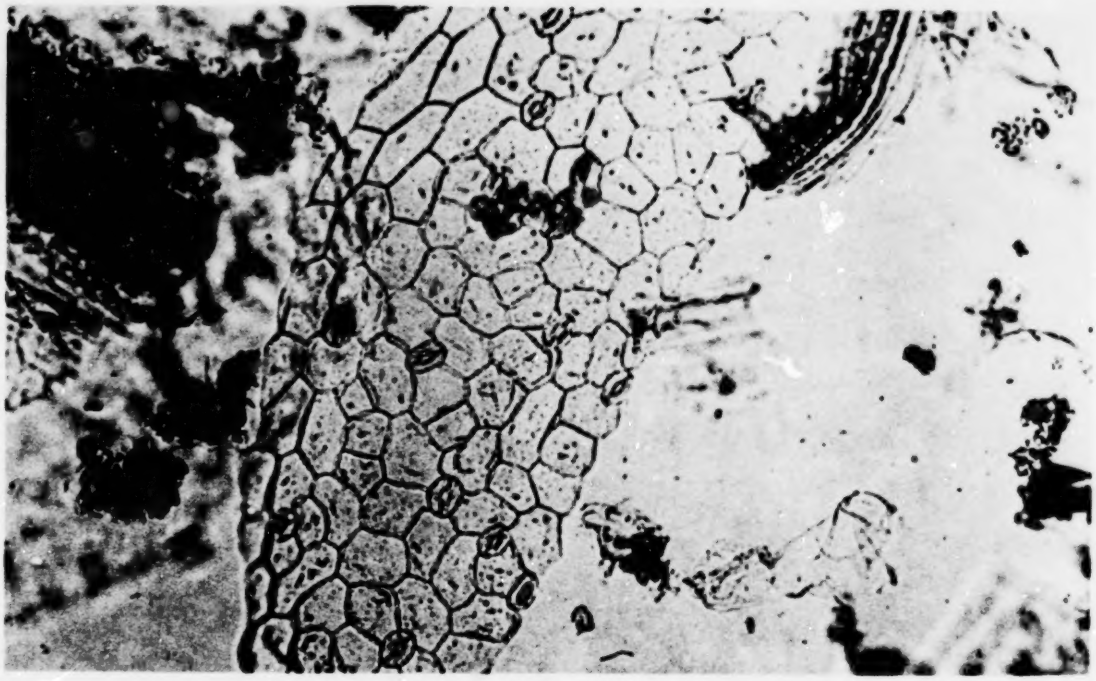
Lupinus sericeus (108)



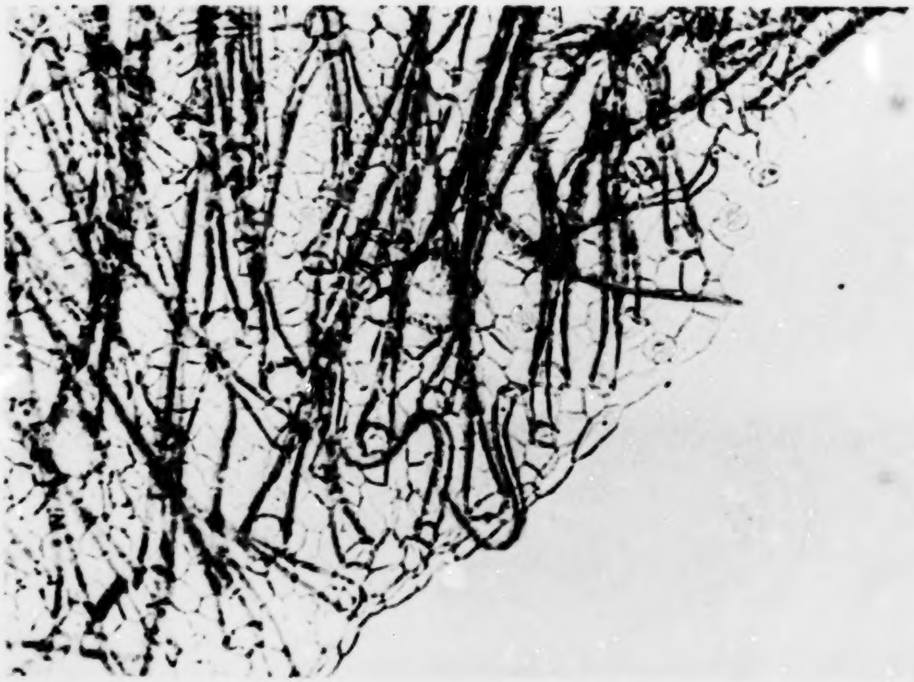
Medicago sativa (109)



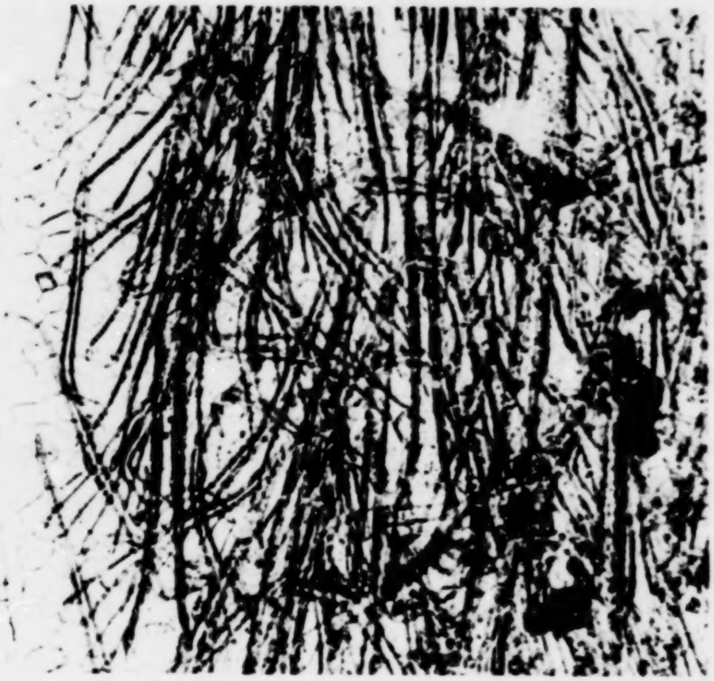
Microseris troximoides (110)



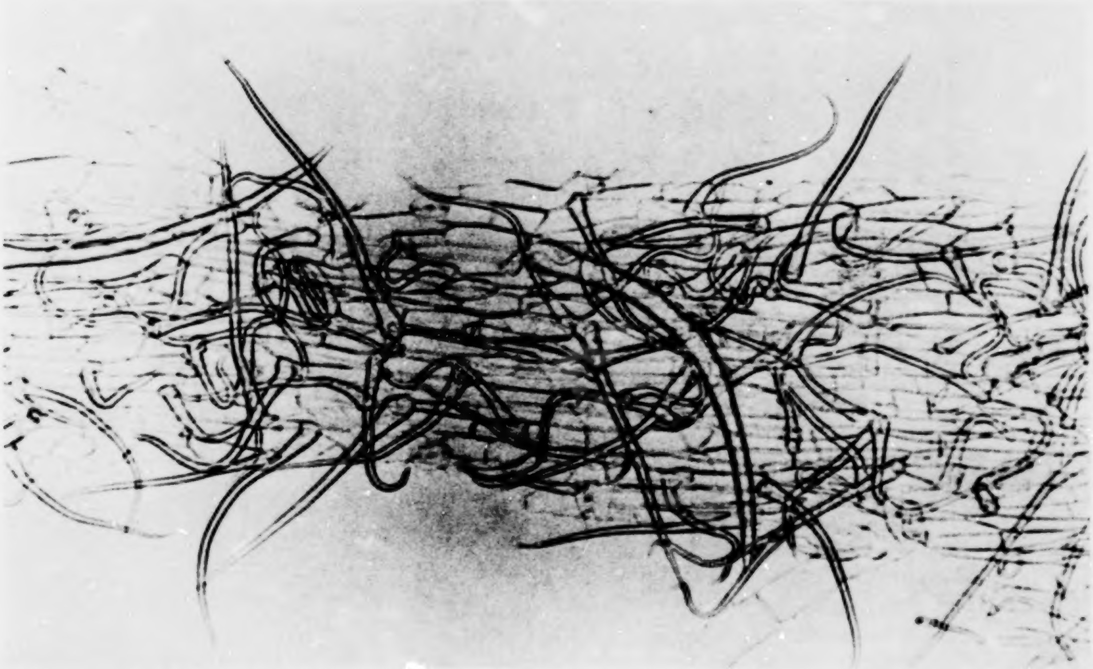
Microseris troximoides (111)



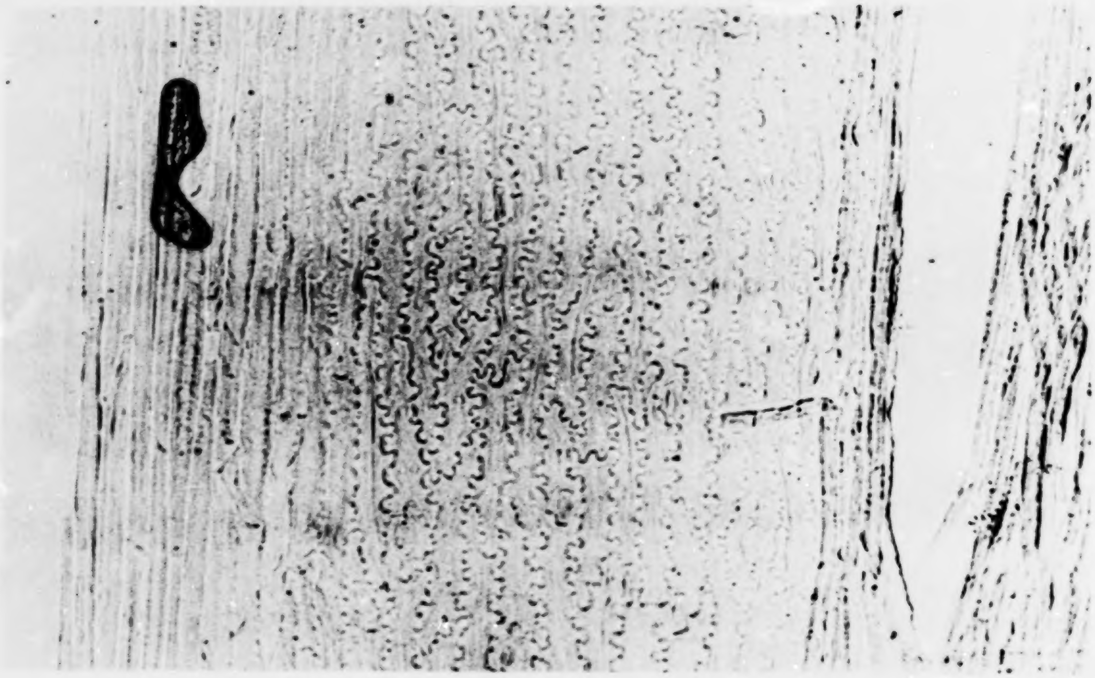
Phacelia hastata (112)



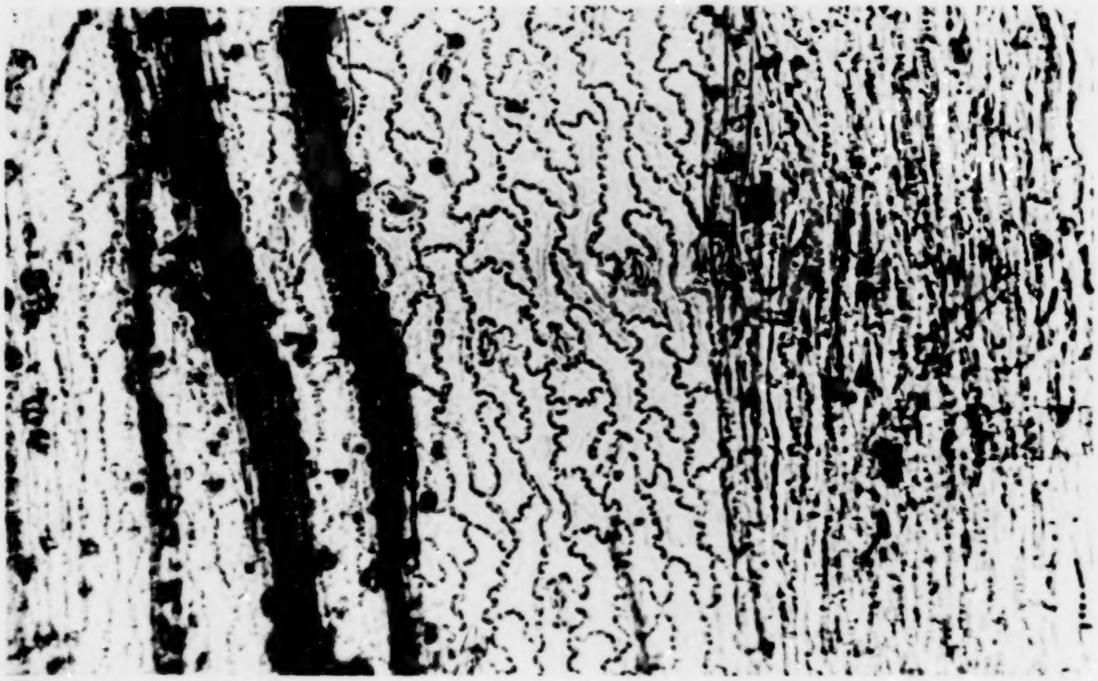
Phacelia hastata (113)



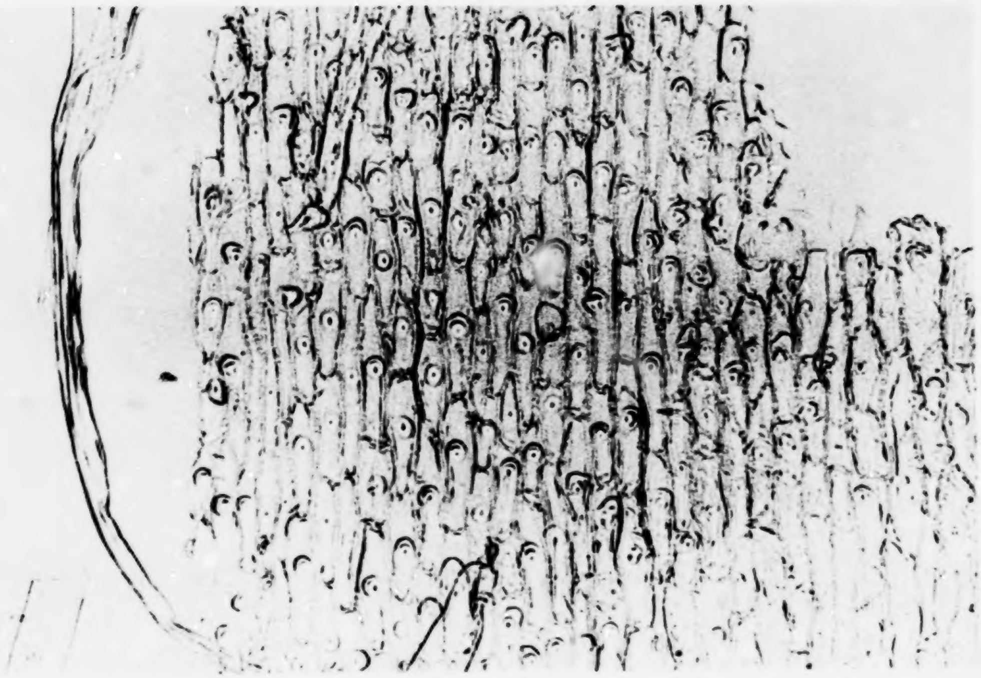
Phacelia hastata (114)



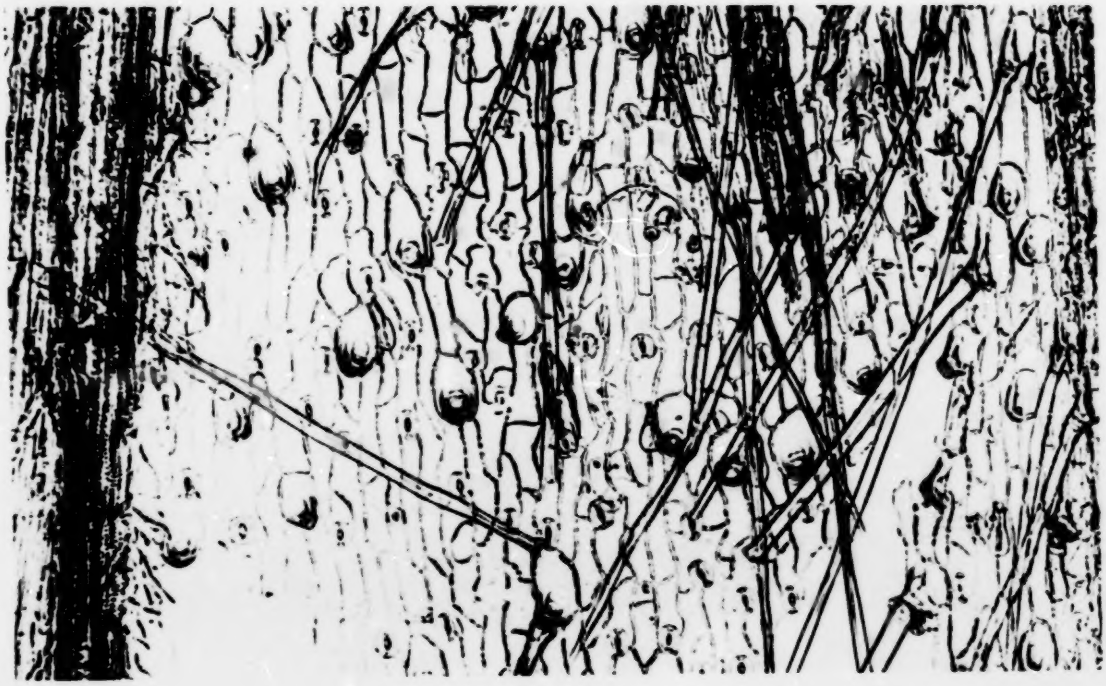
Phlox longifolia (115)



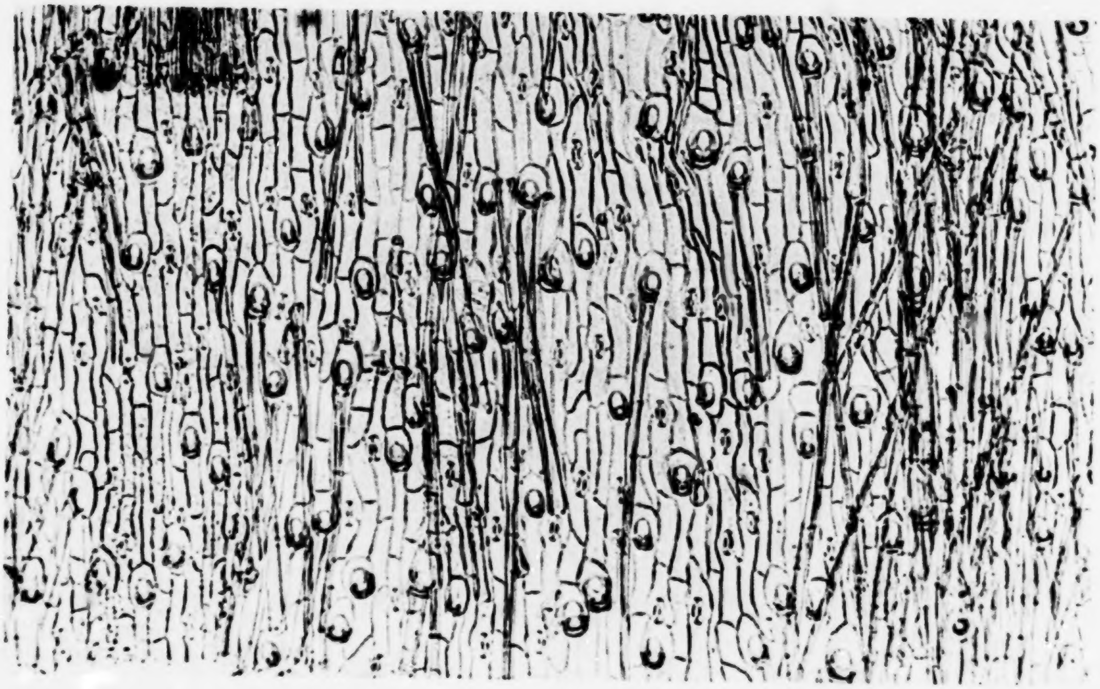
Phlox longifolia (116)



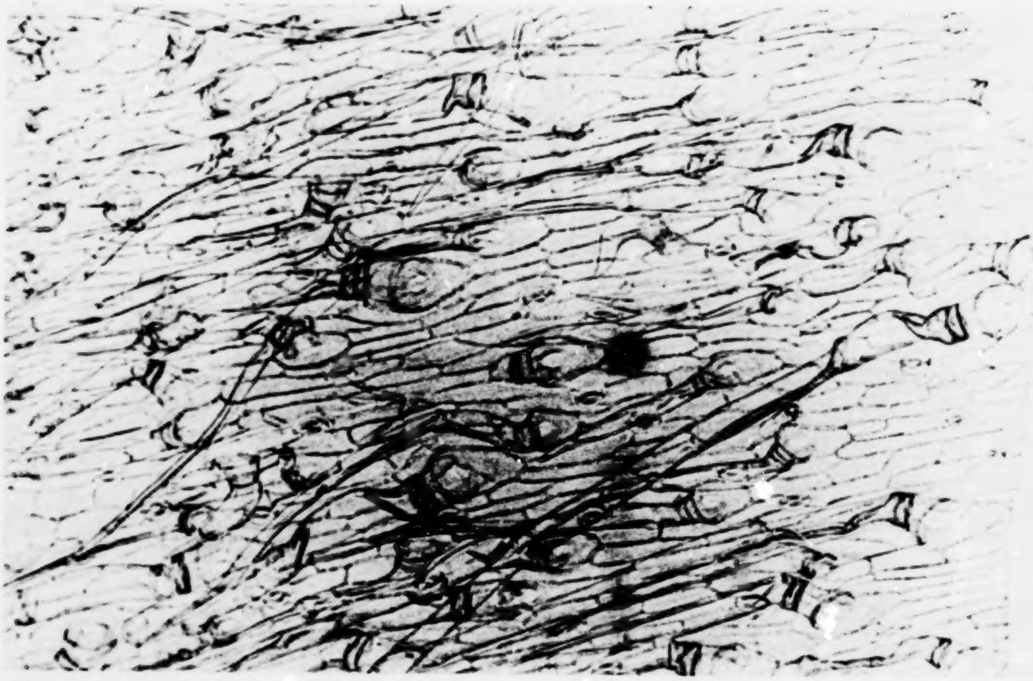
Phlox longifolia (117)



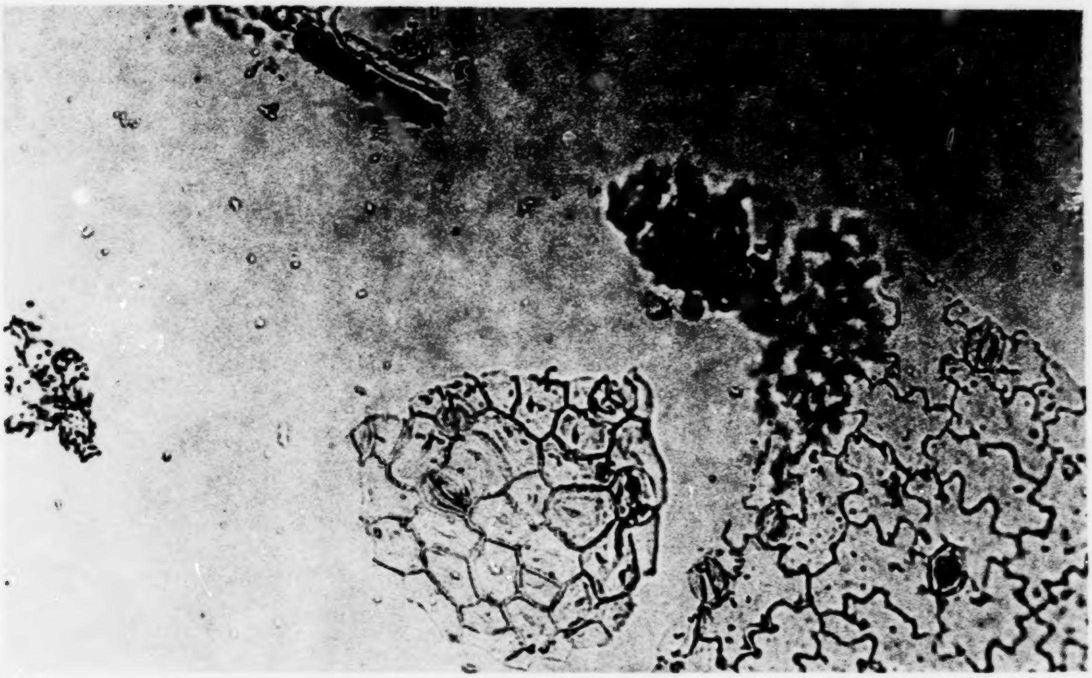
Plantago patagonica (118)



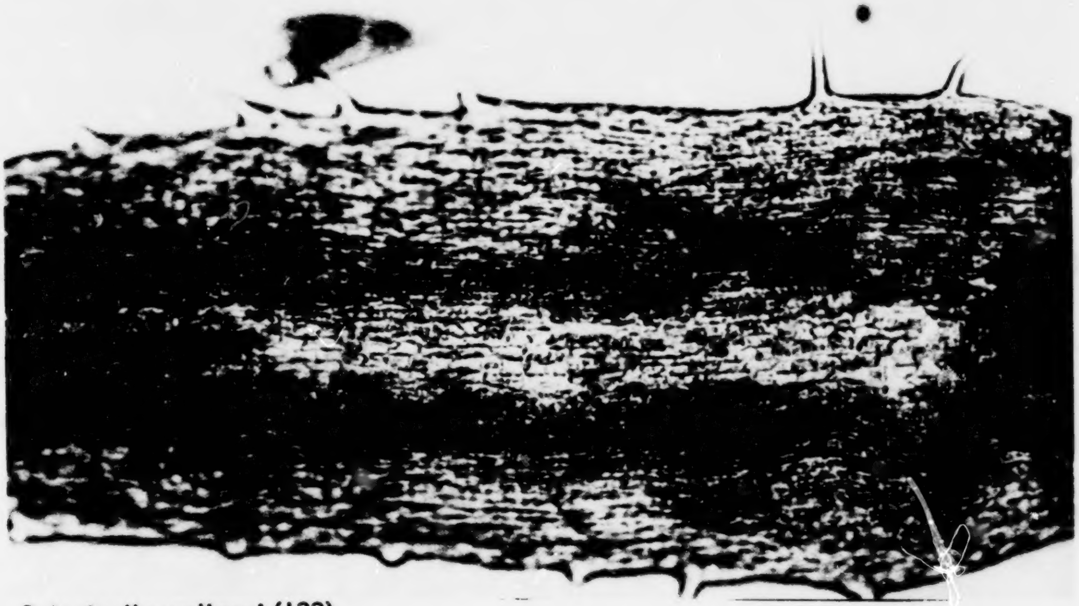
Plantago patagonica (119)



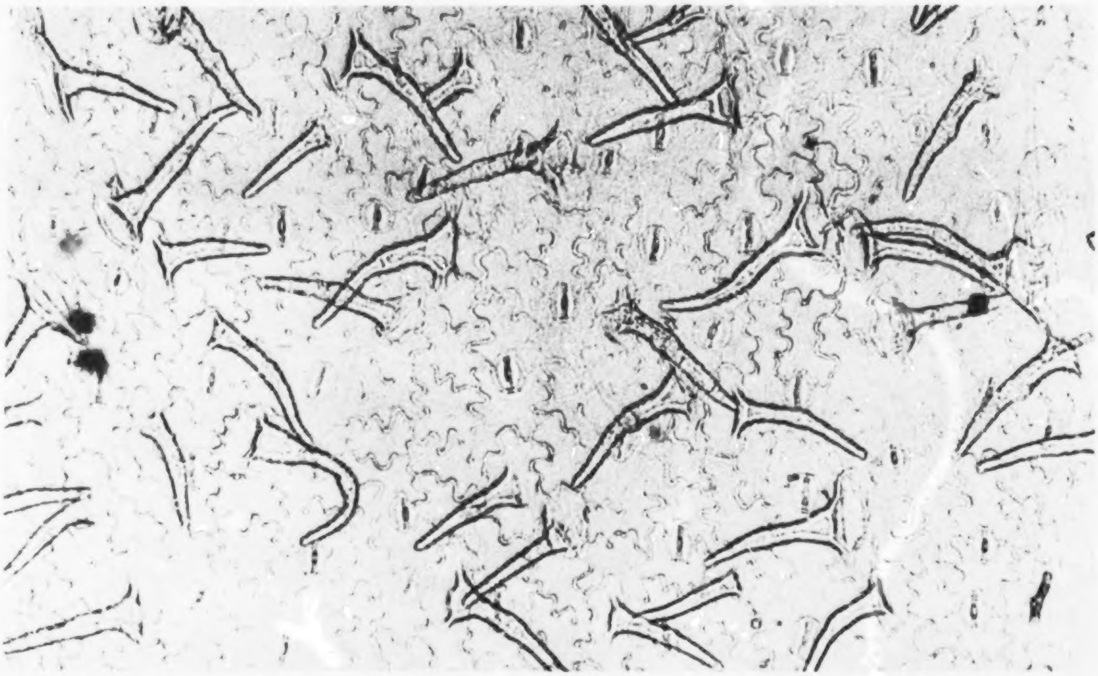
Plantago patagonica (120)



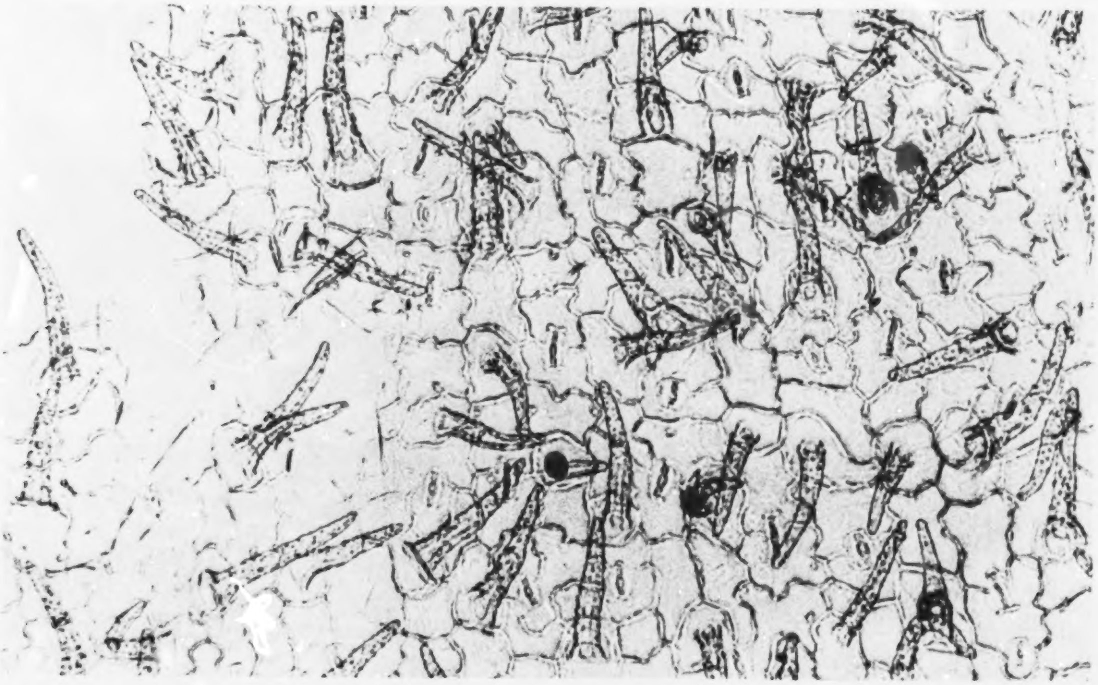
Ranunculus glaberrimus (121)



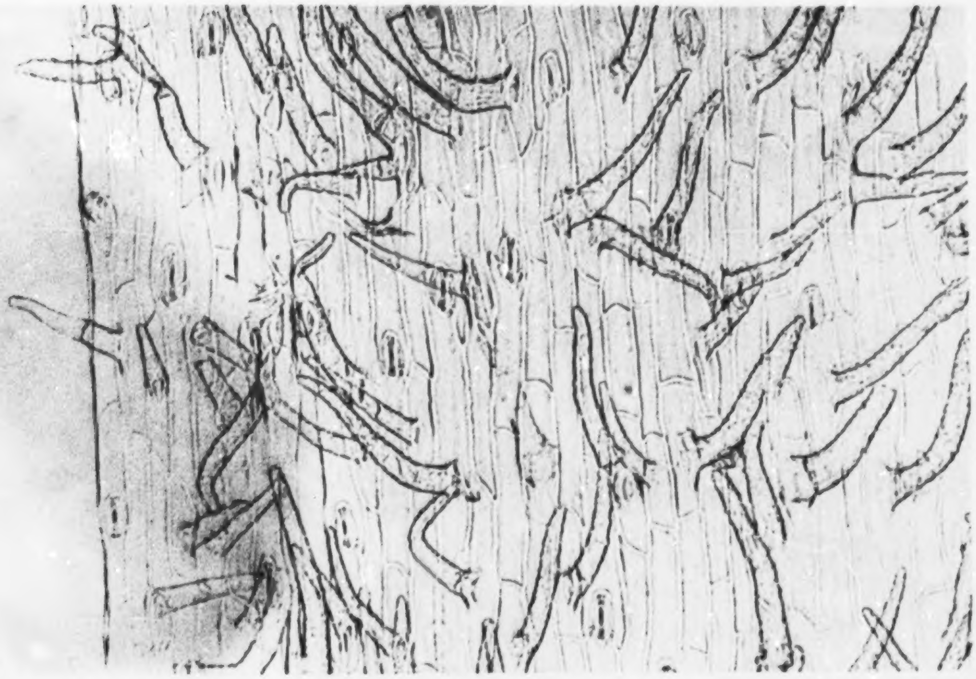
Selaginella wallacei (122)



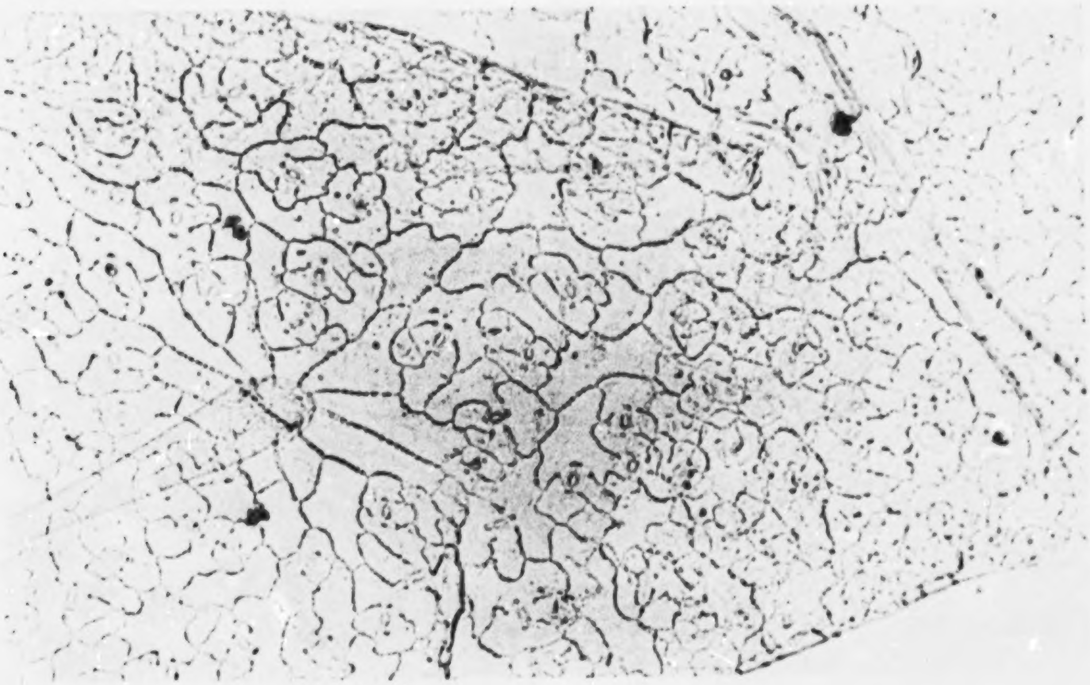
Silene noctiflora (123)



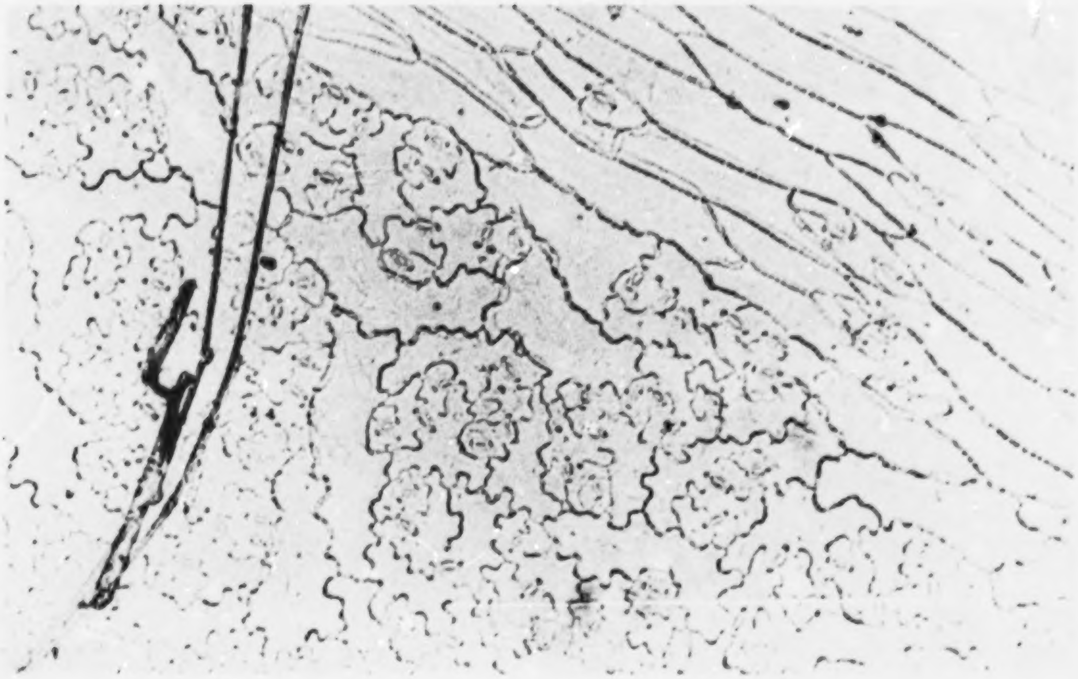
Silene noctiflora (124)



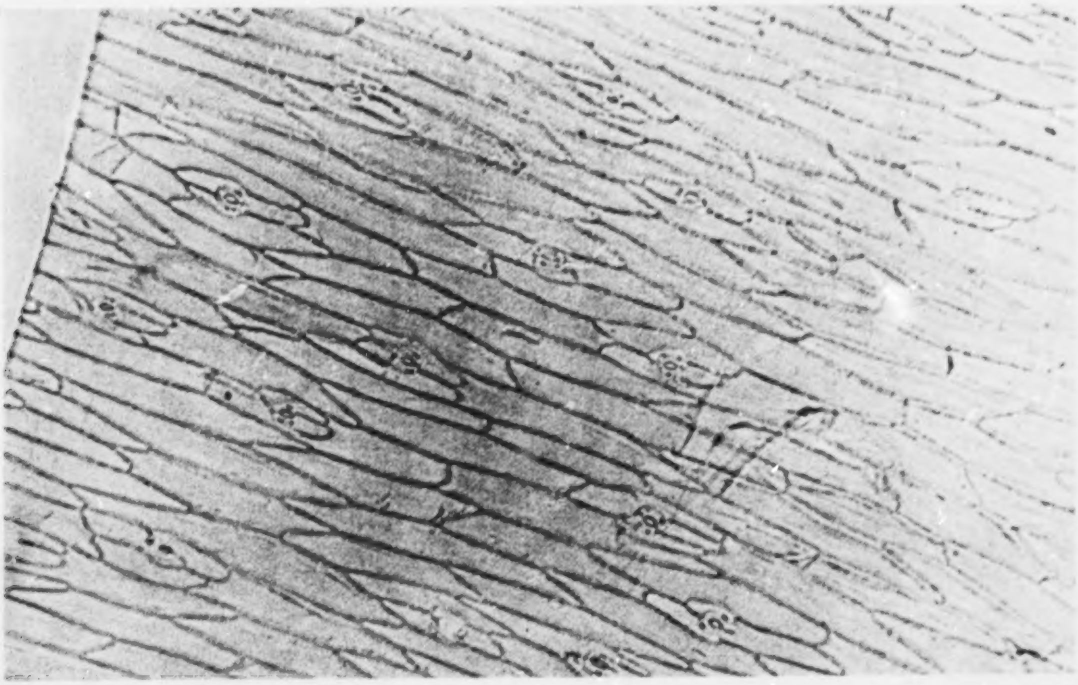
Silene noctiflora (125)



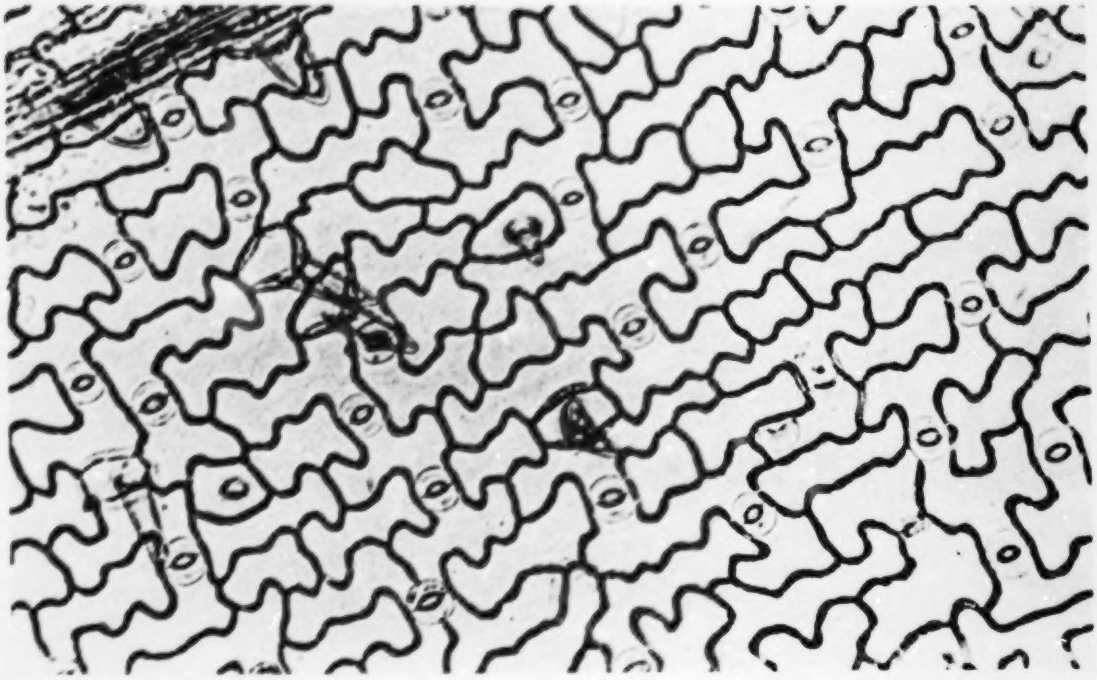
Sisymbrium altissimum (126)



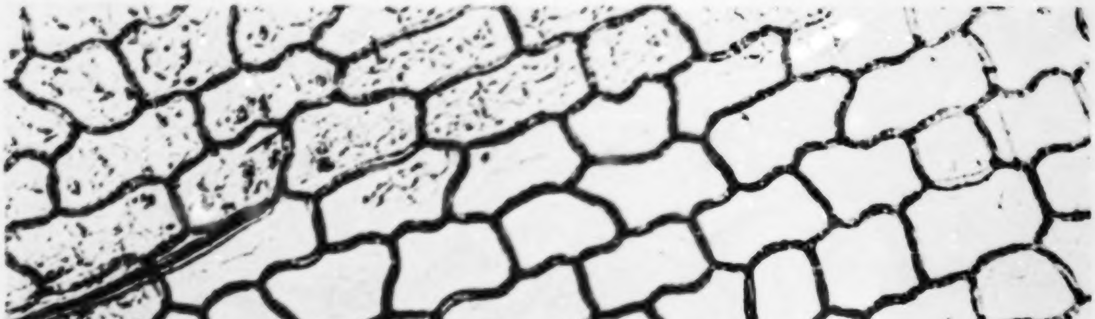
Sisymbrium altissimum (127)



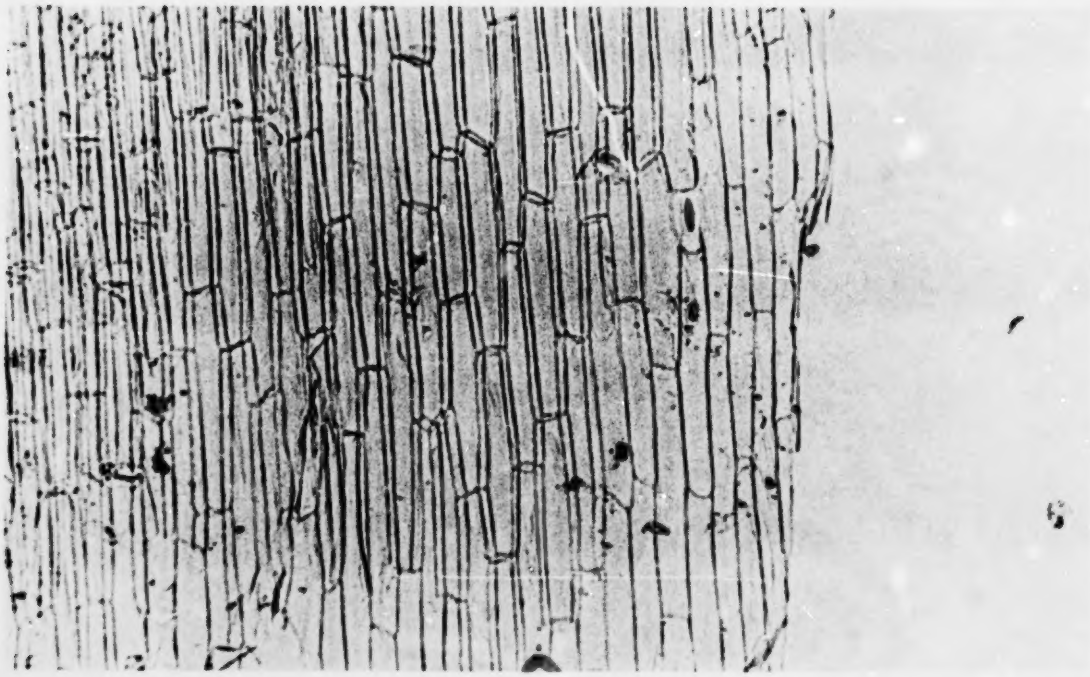
Sisymbrium altissimum (128)



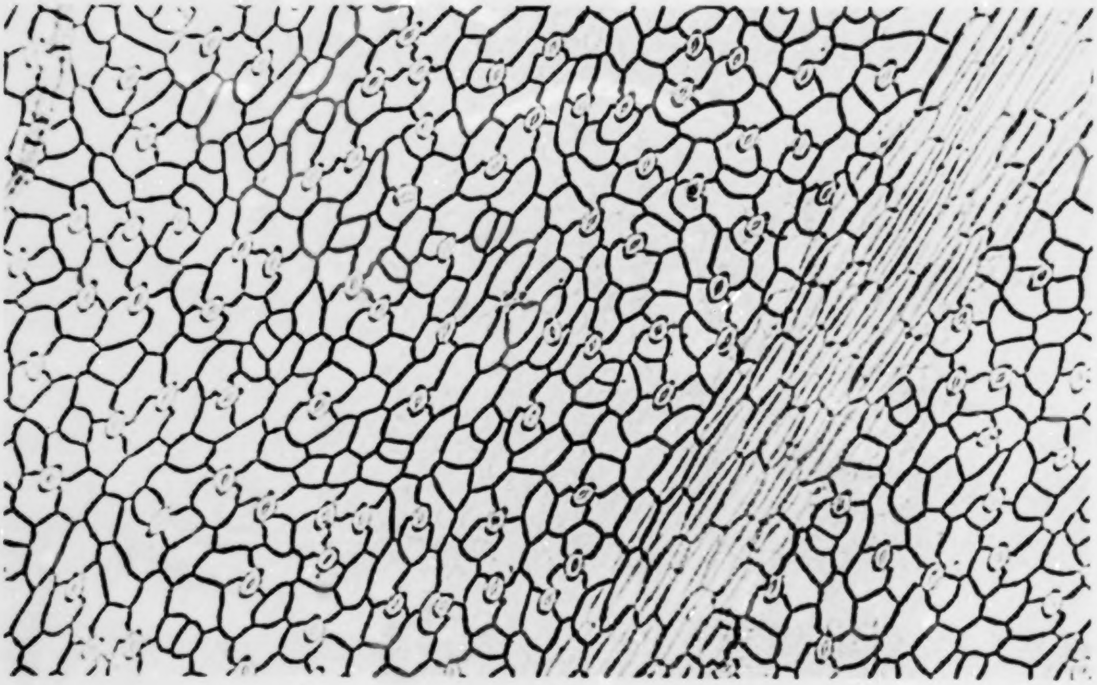
Smilacina racemosa (129)



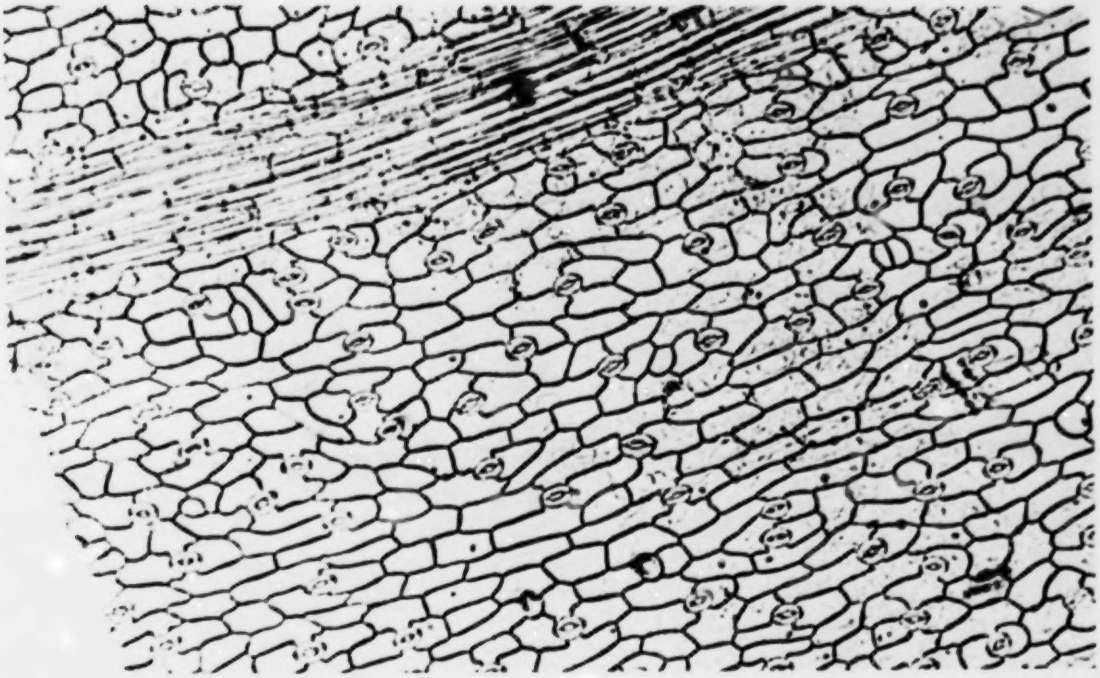
Smilacina racemosa (130)



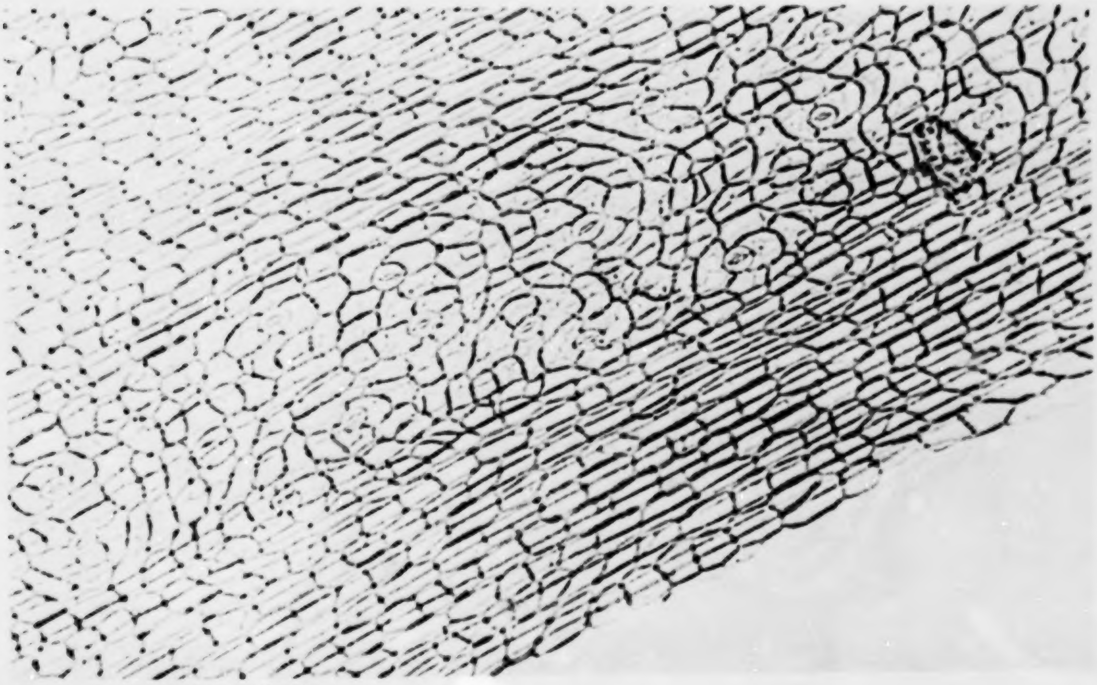
Smilacina racemosa (131)



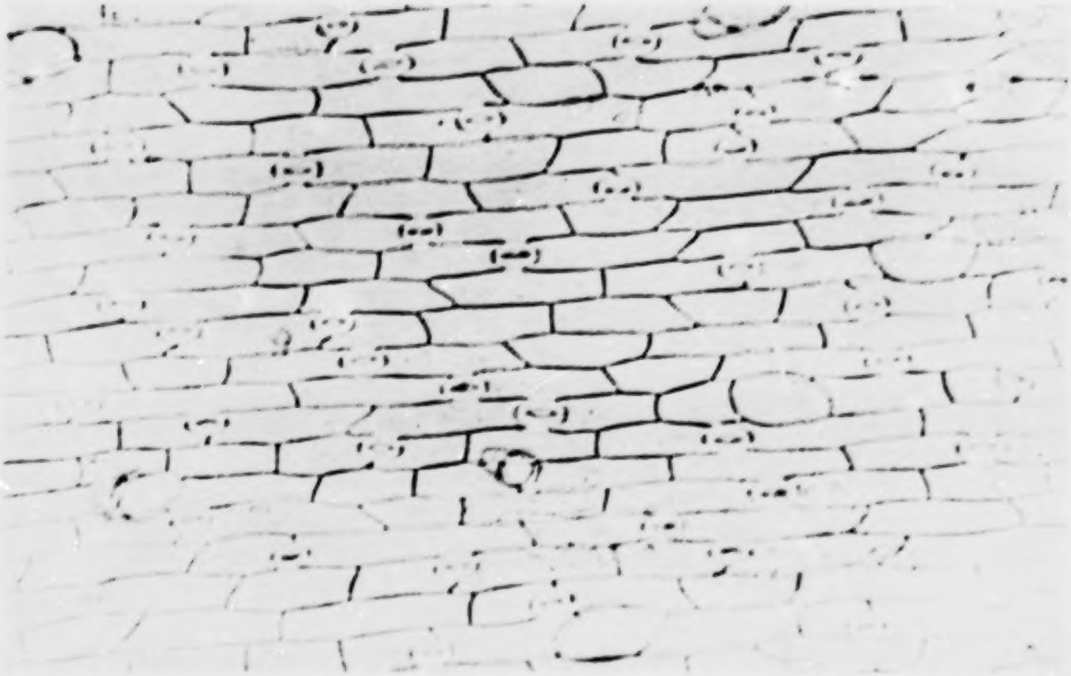
Tragopogon dubius (132)



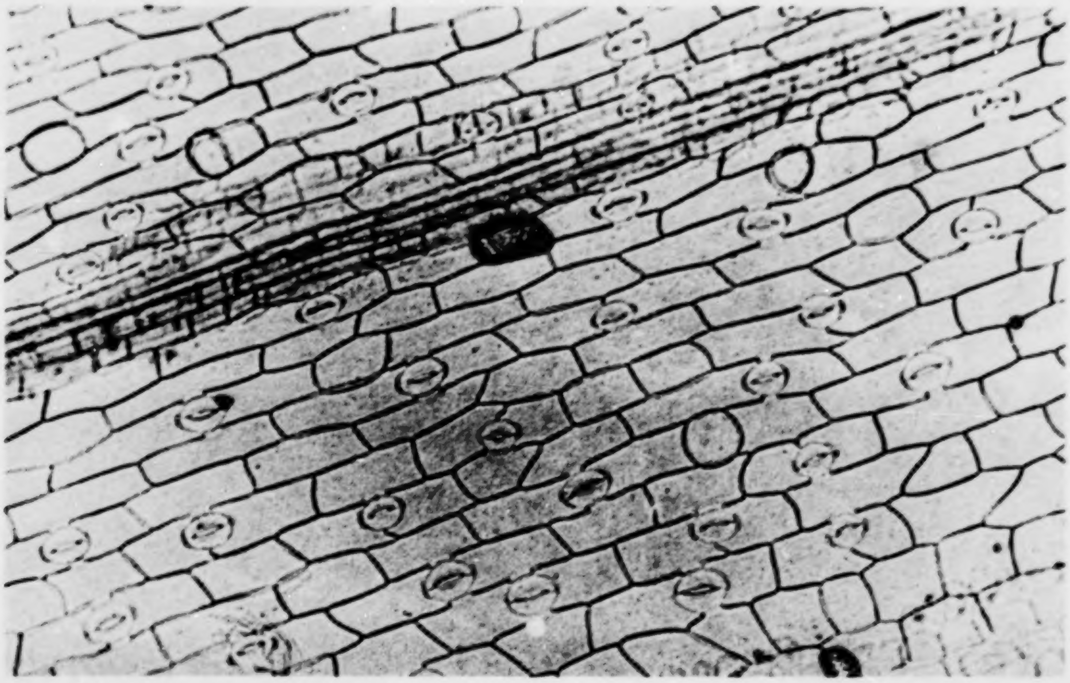
Tragopogon dubius (133)



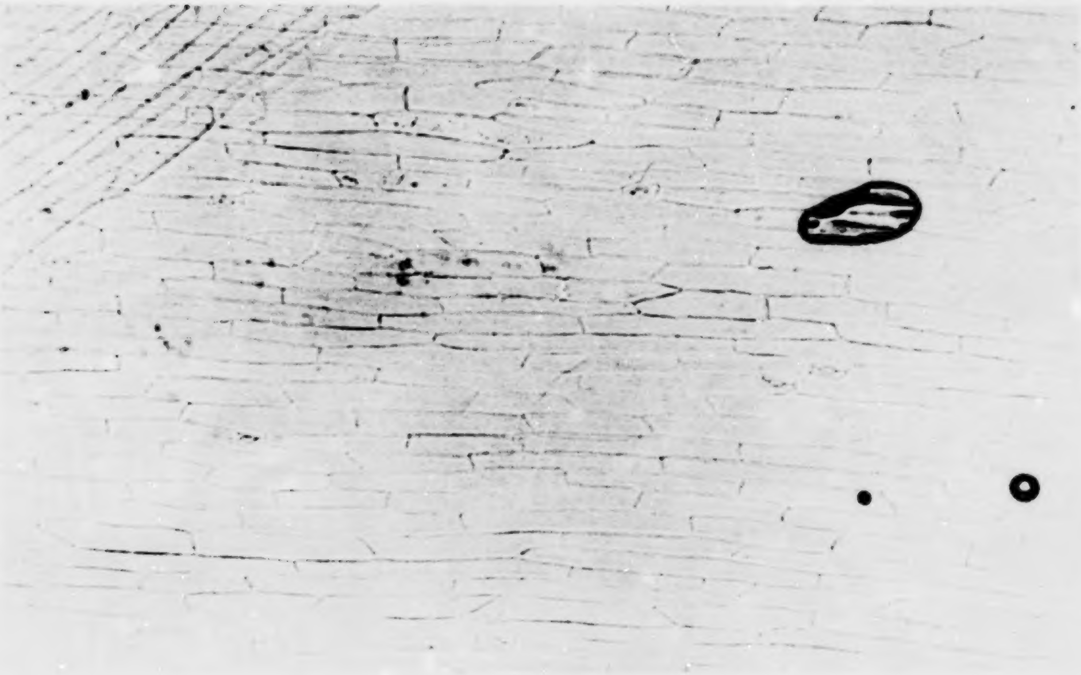
Tragopogon dubius (134)



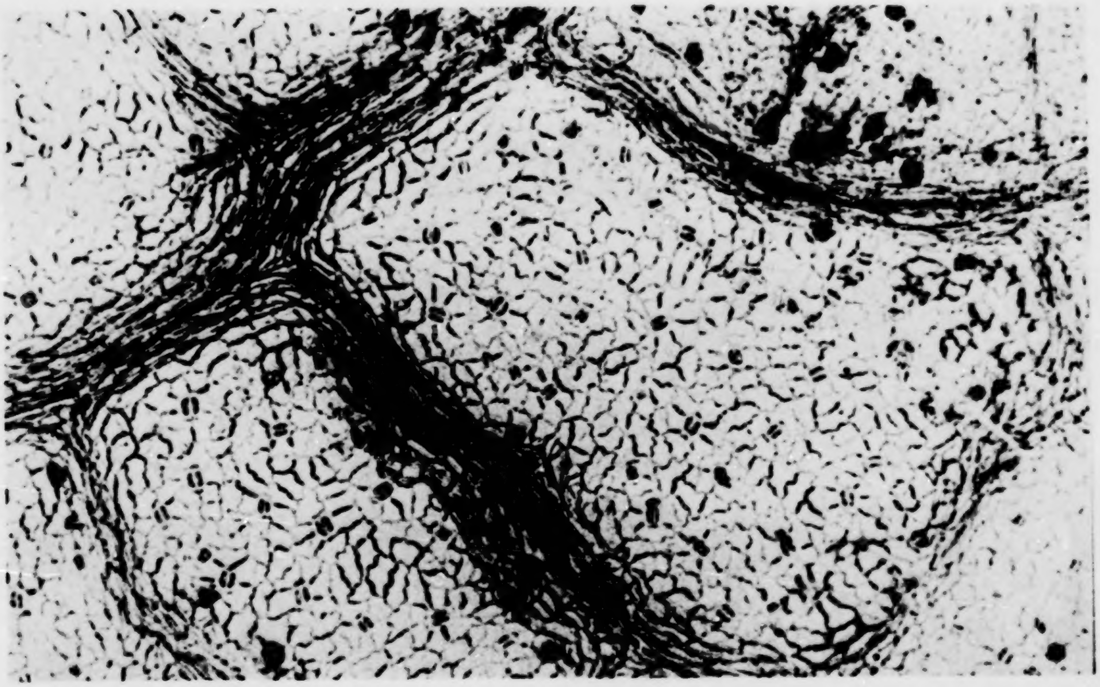
Zigadenus venenosus (135)



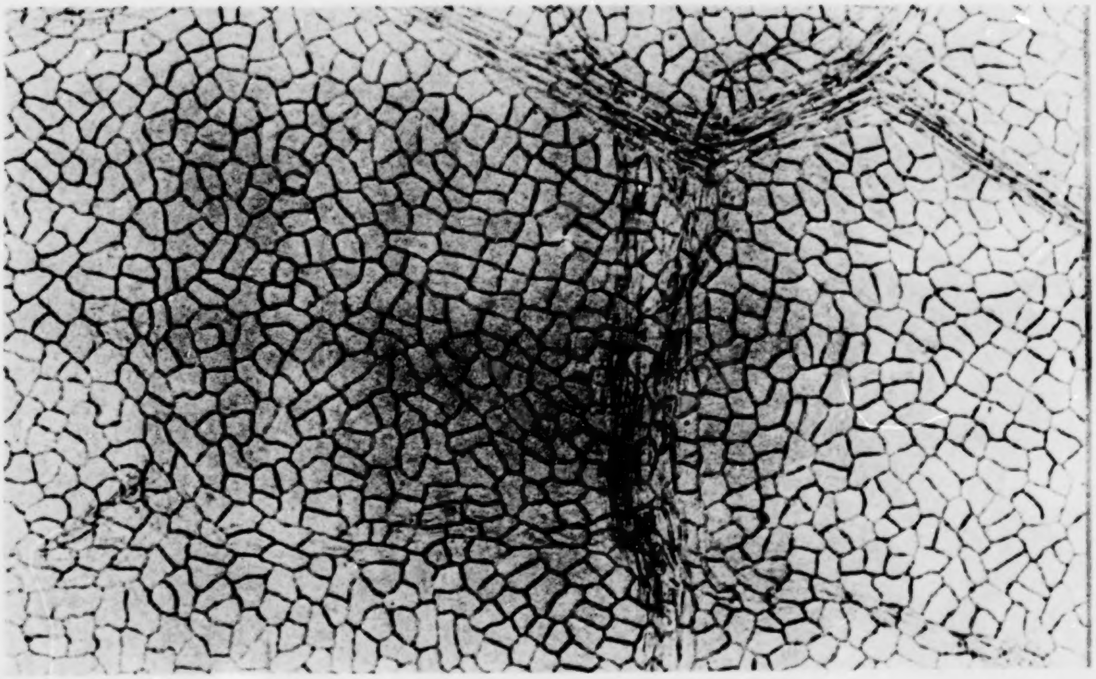
Zigadenus venenosus (136)



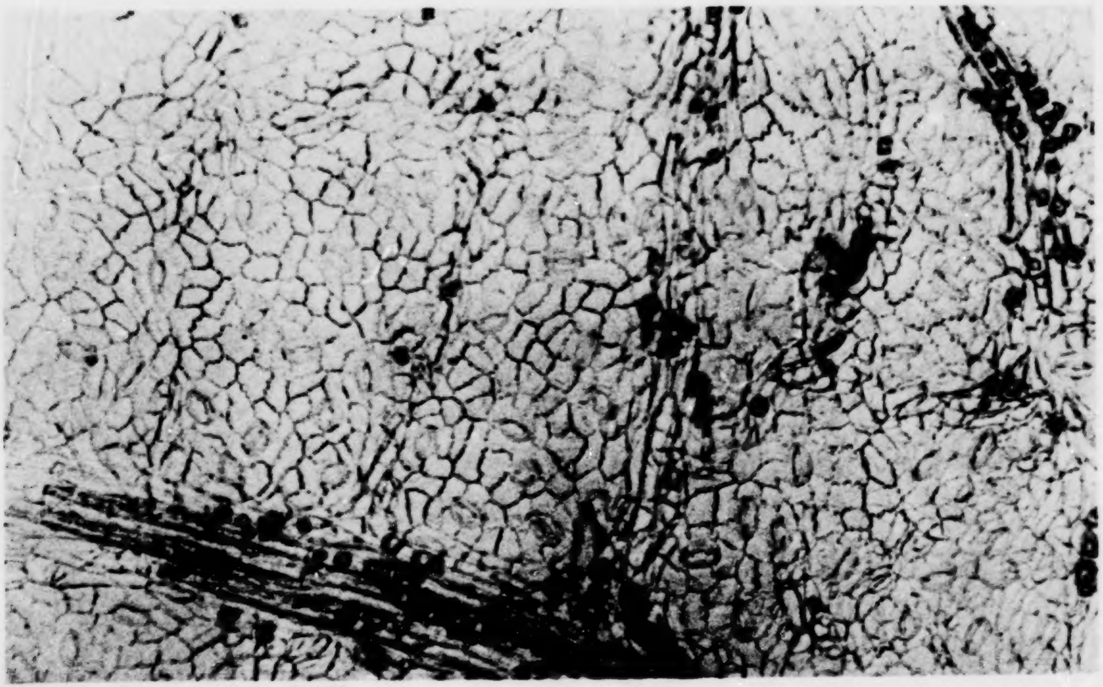
Zigadenus venenosus (137)



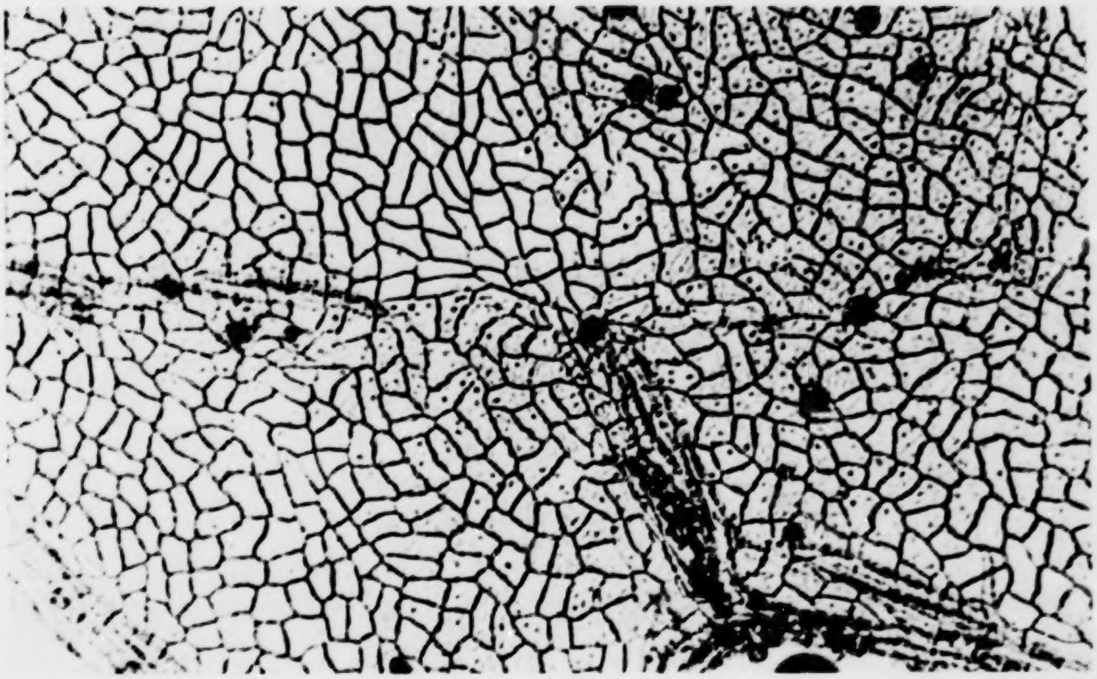
Acer glabrum (138)



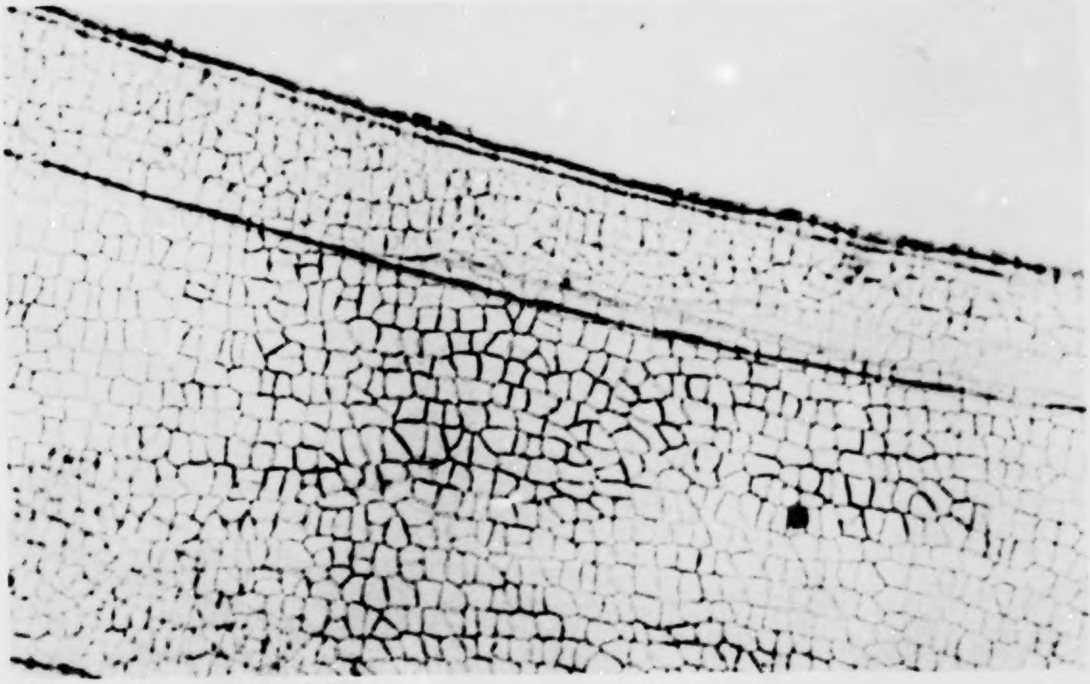
Acer glabrum (139)



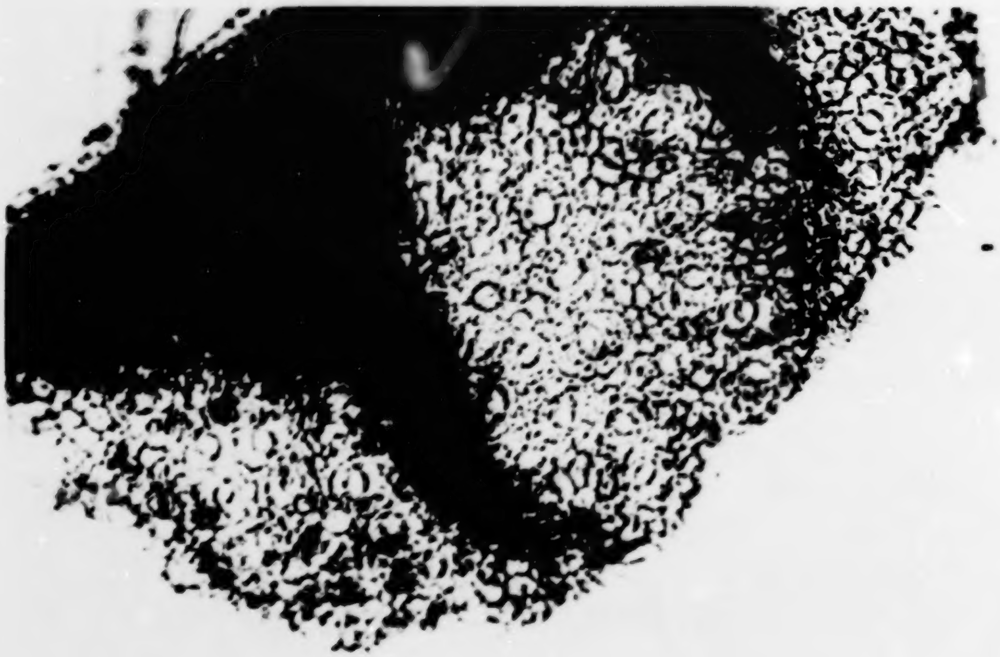
Amelanchier alnifolia (140)



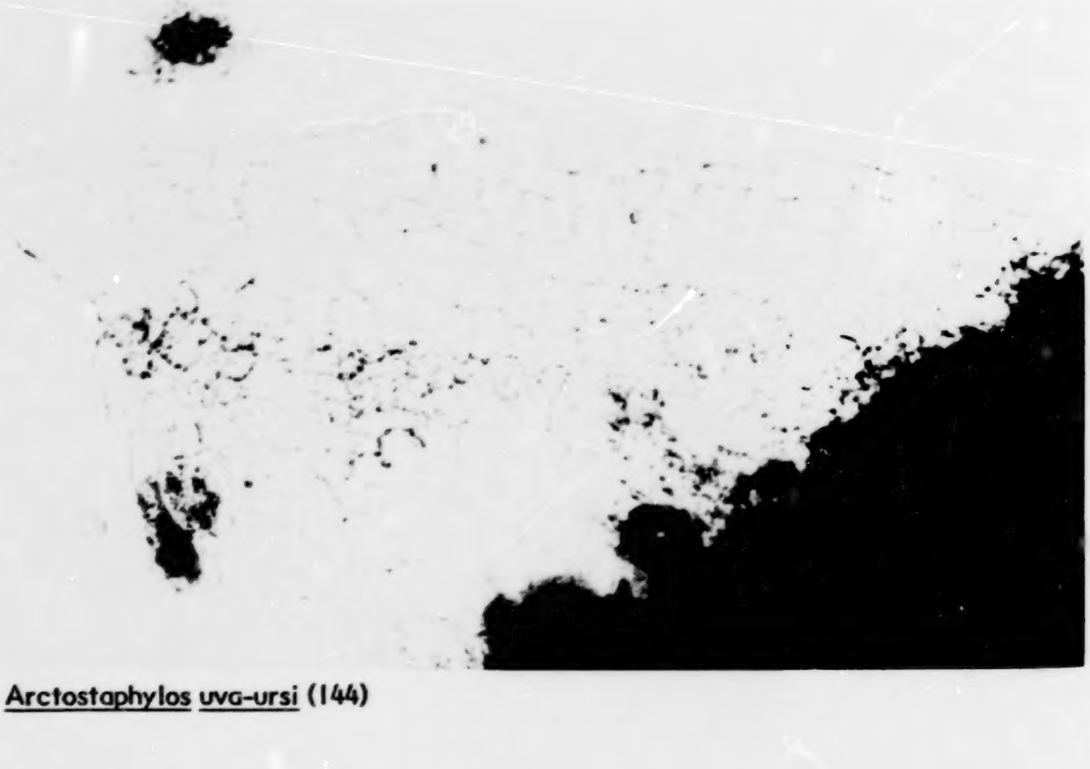
Amelanchier alnifolia (141)



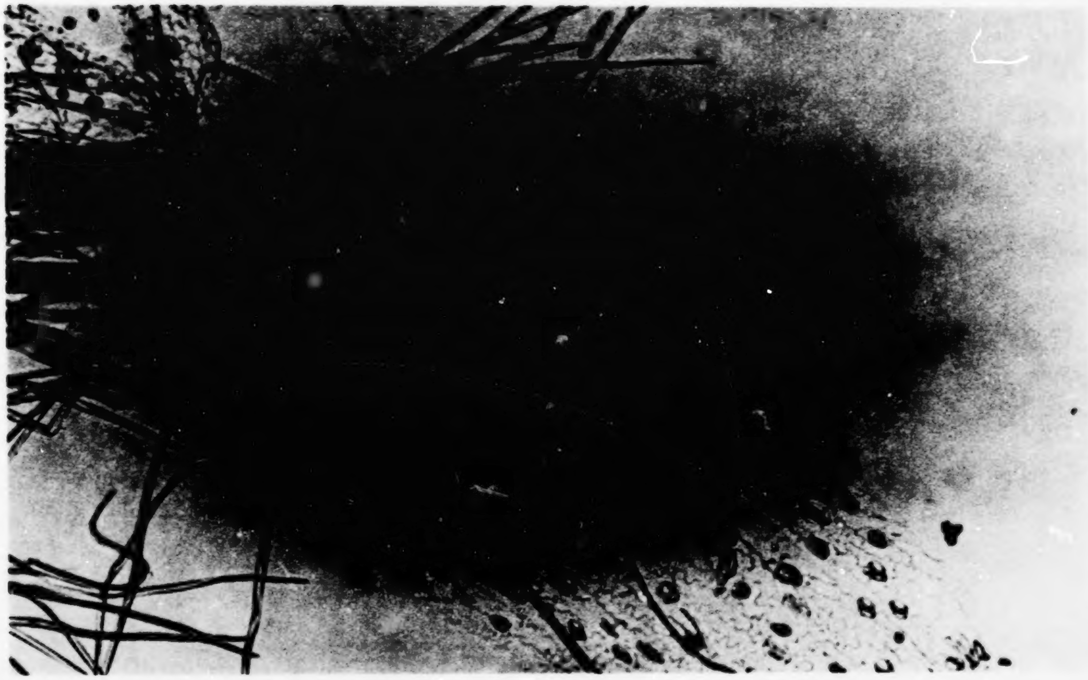
Amelanchier alnifolia (142)



Arctostaphylos uva-ursi (143)

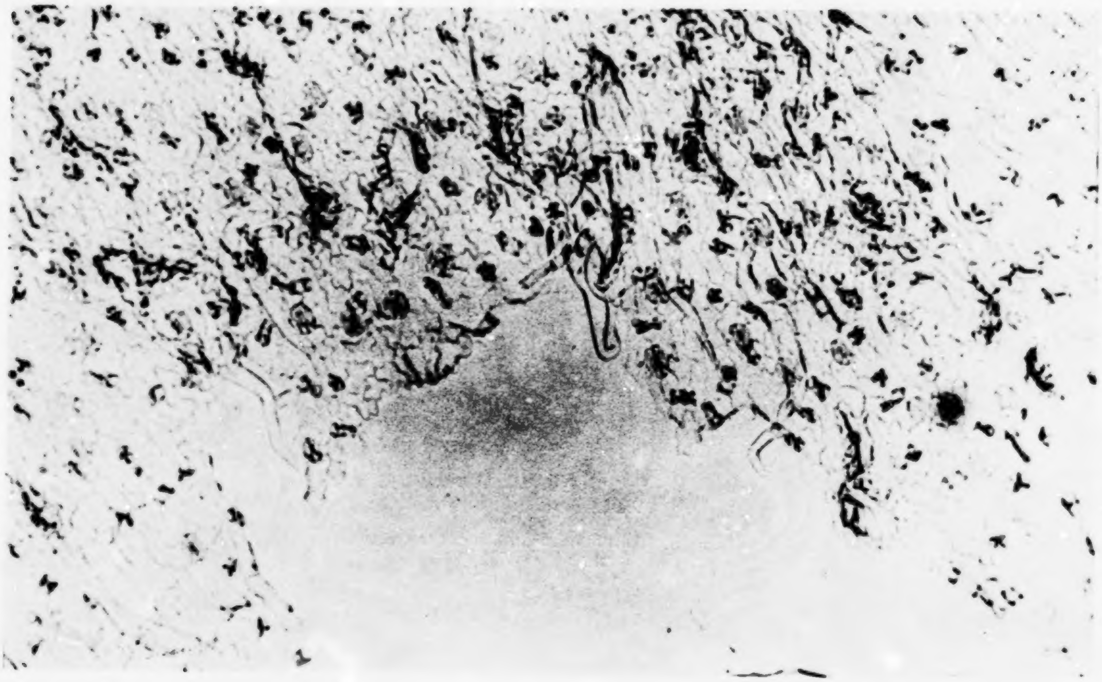


Arctostaphylos uva-ursi (144)

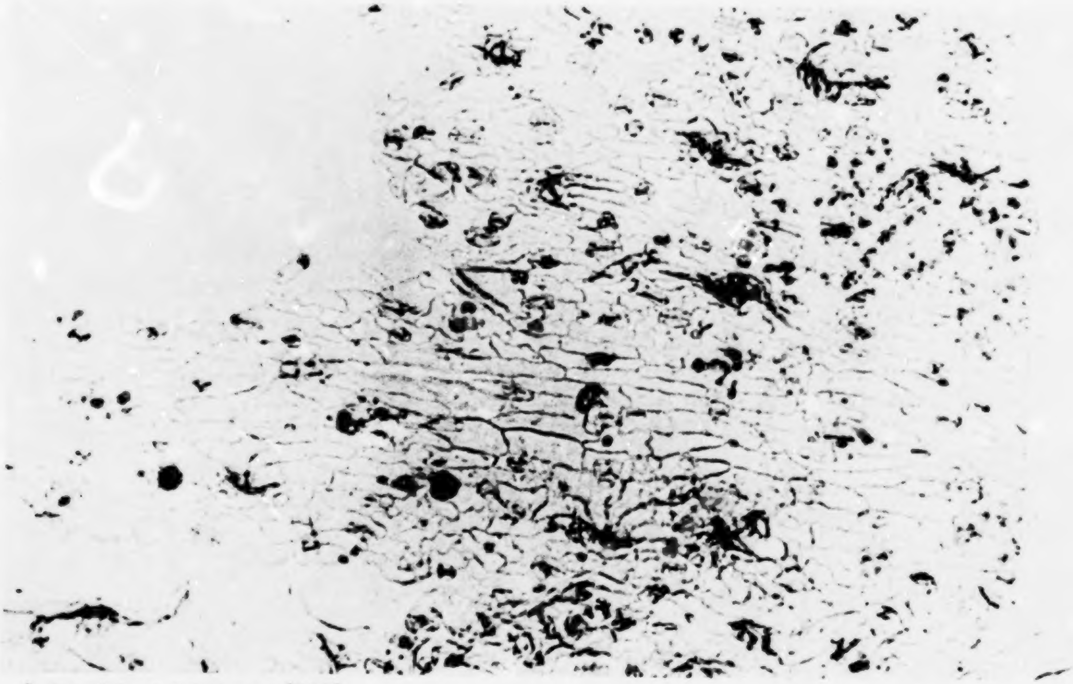


Artemisia frigida (145)

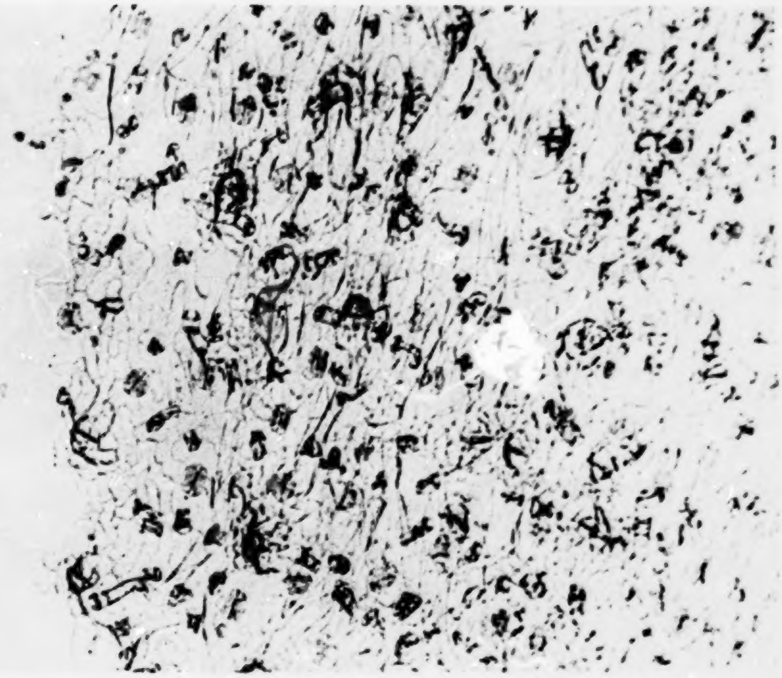
Artemisia frigida (146)



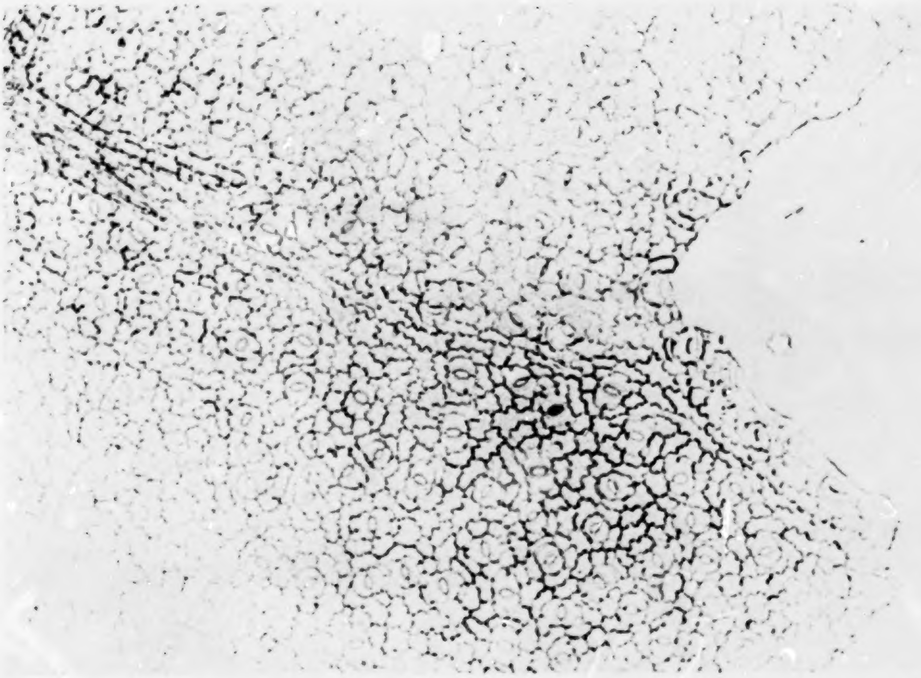
Artemisia tridentata (147)



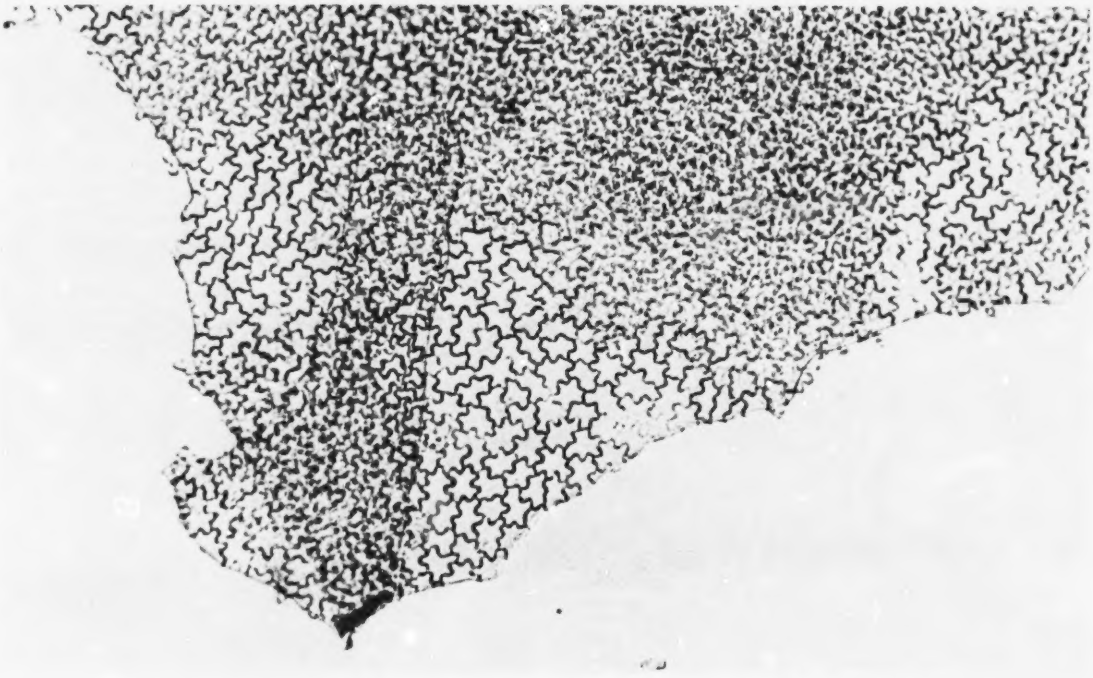
Artemisia tridentata (148)



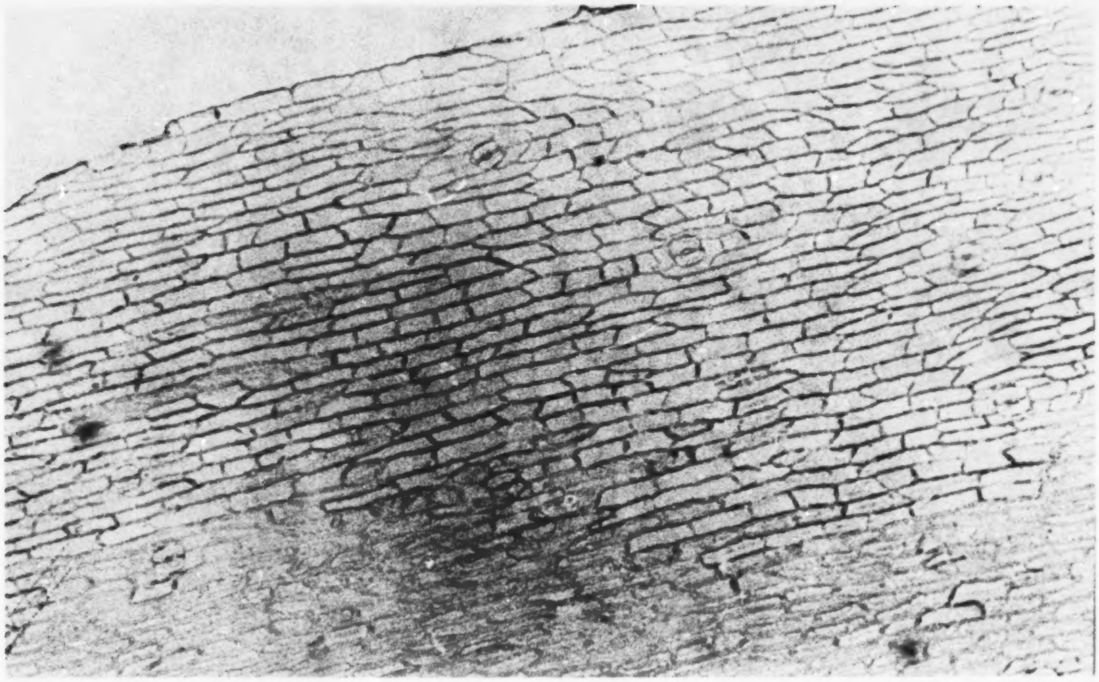
Artemisia tridentata (149)



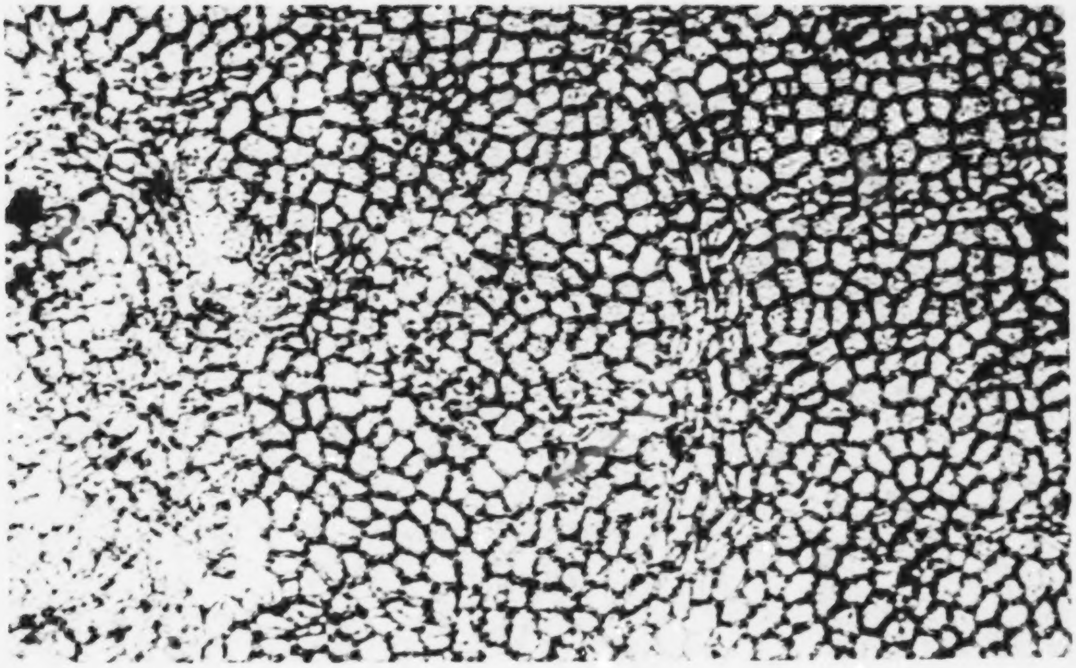
Berberis aquifolium (150)



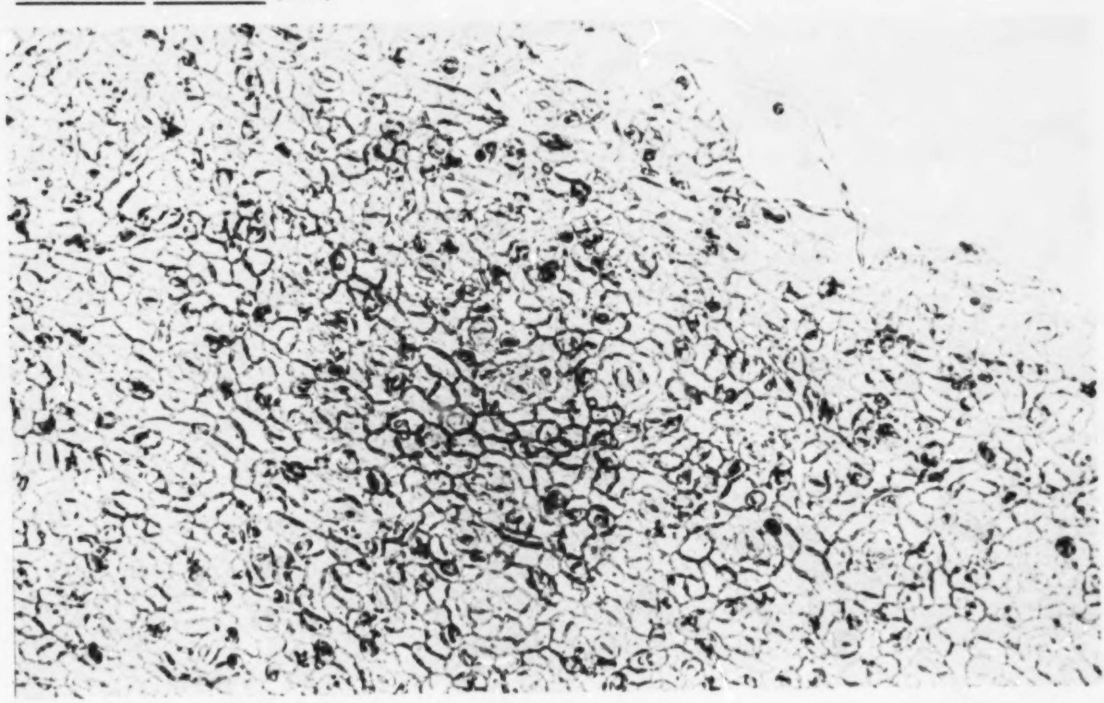
Berberis aquifolium (151)



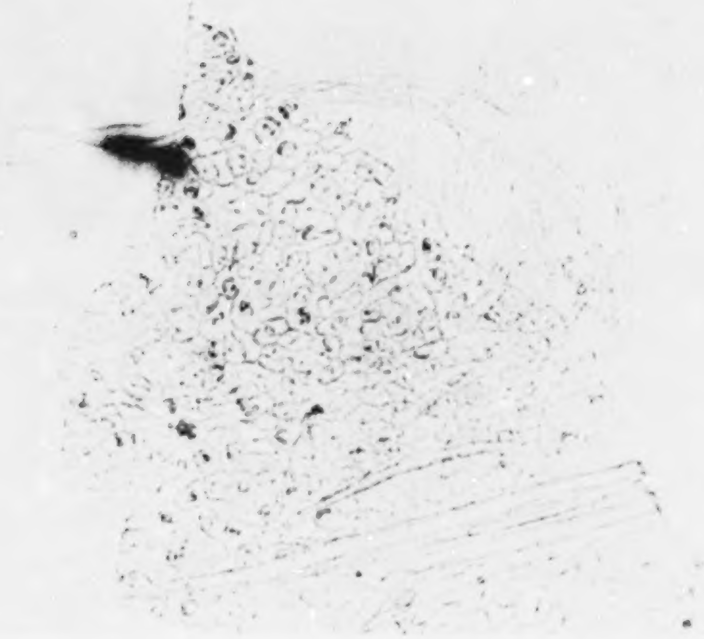
Berberis aquifolium (152)



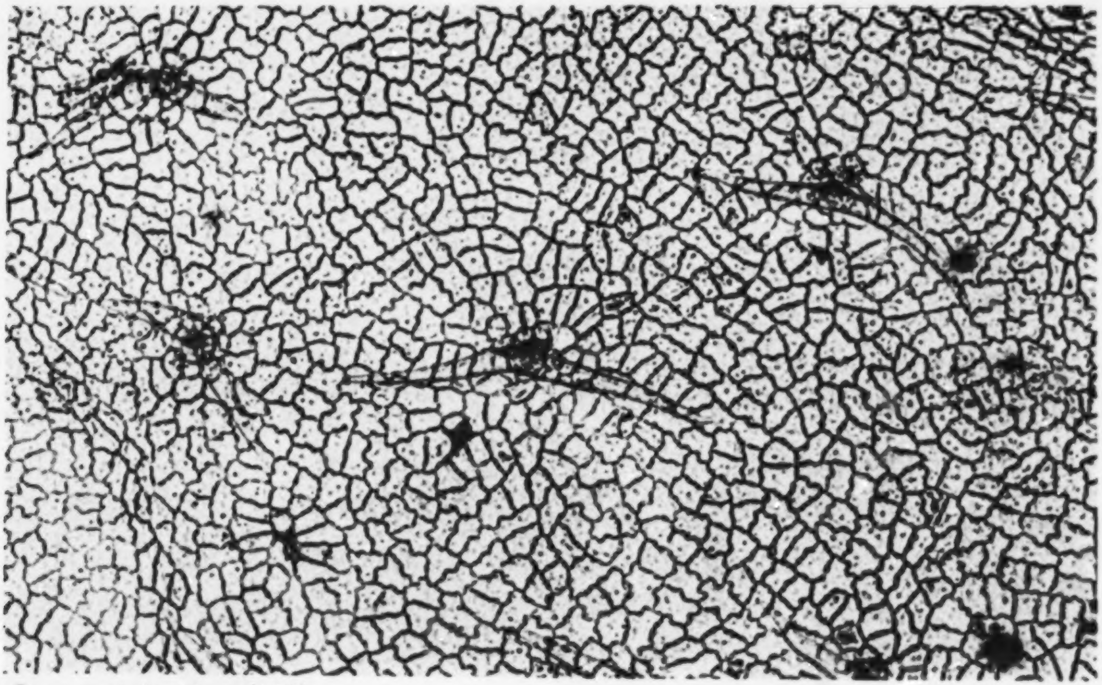
Ceanothus velutinus (153)



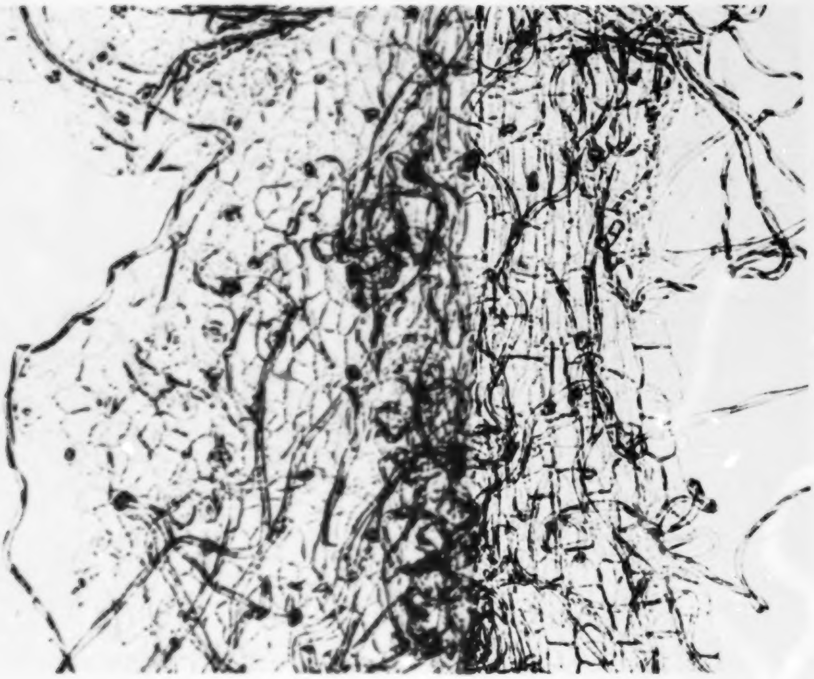
Chrysothamnus nauseosus (154)



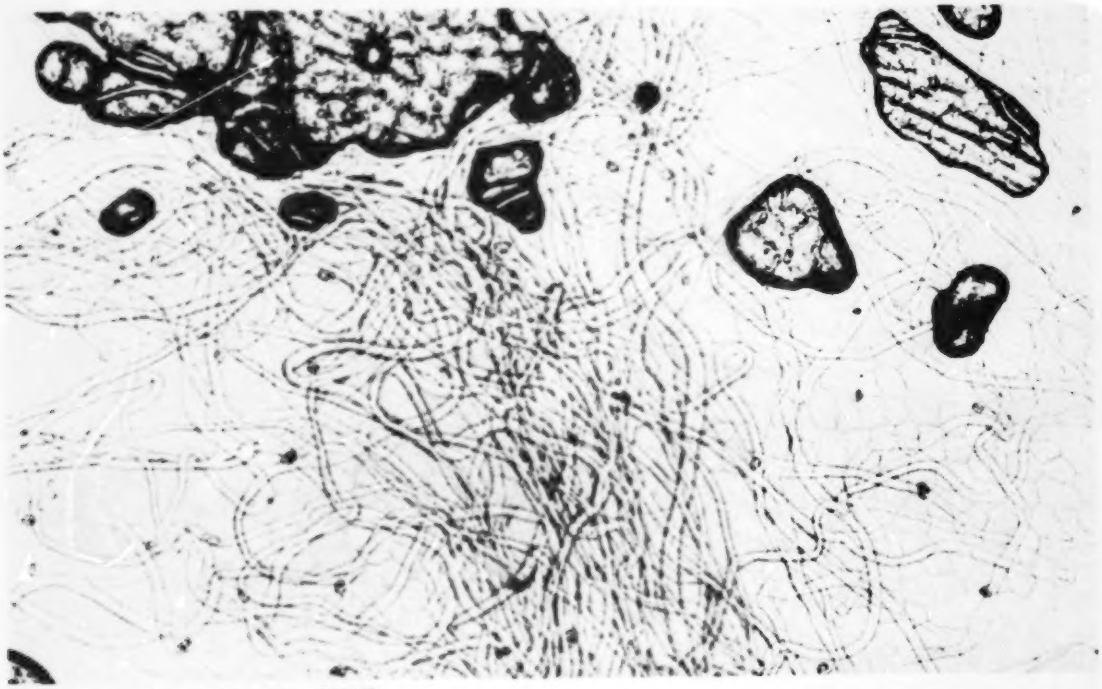
Chrysothamnus nauseosus (155)



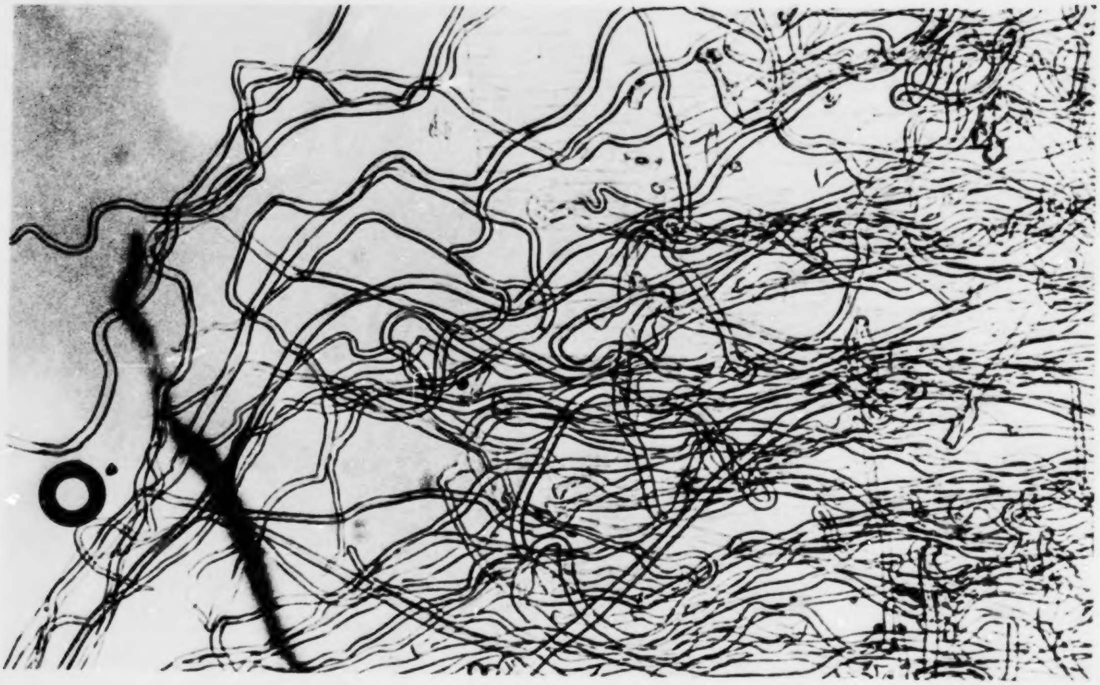
Cornus stolonifera (156)



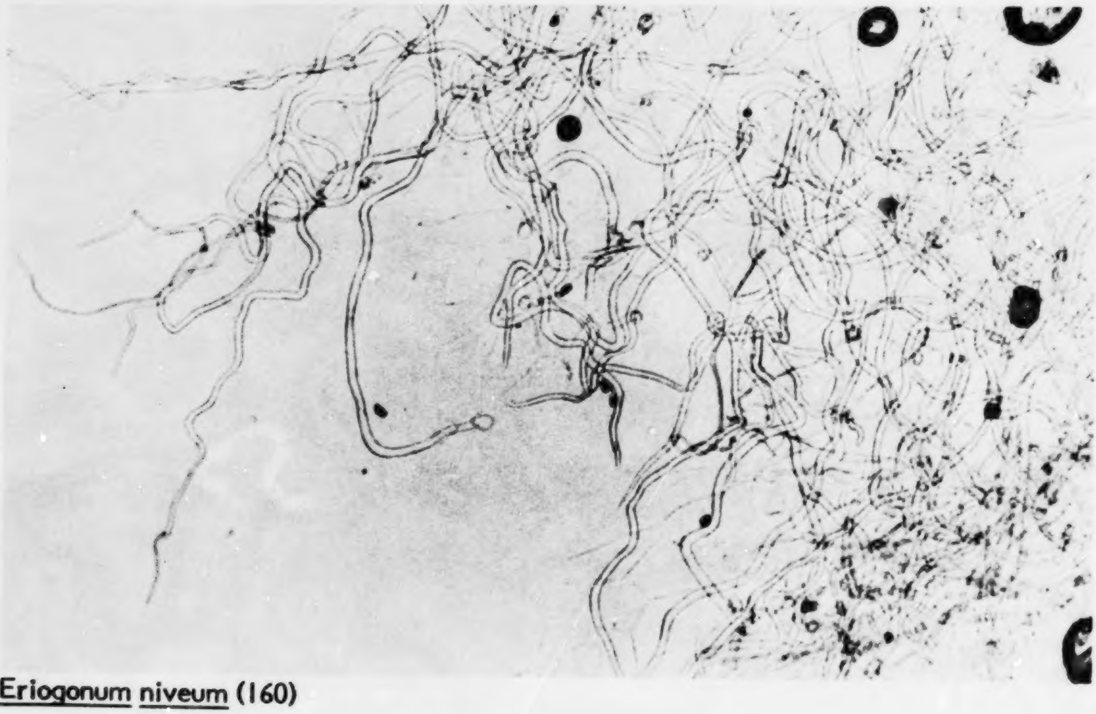
Eriogonum heracleoides (157)



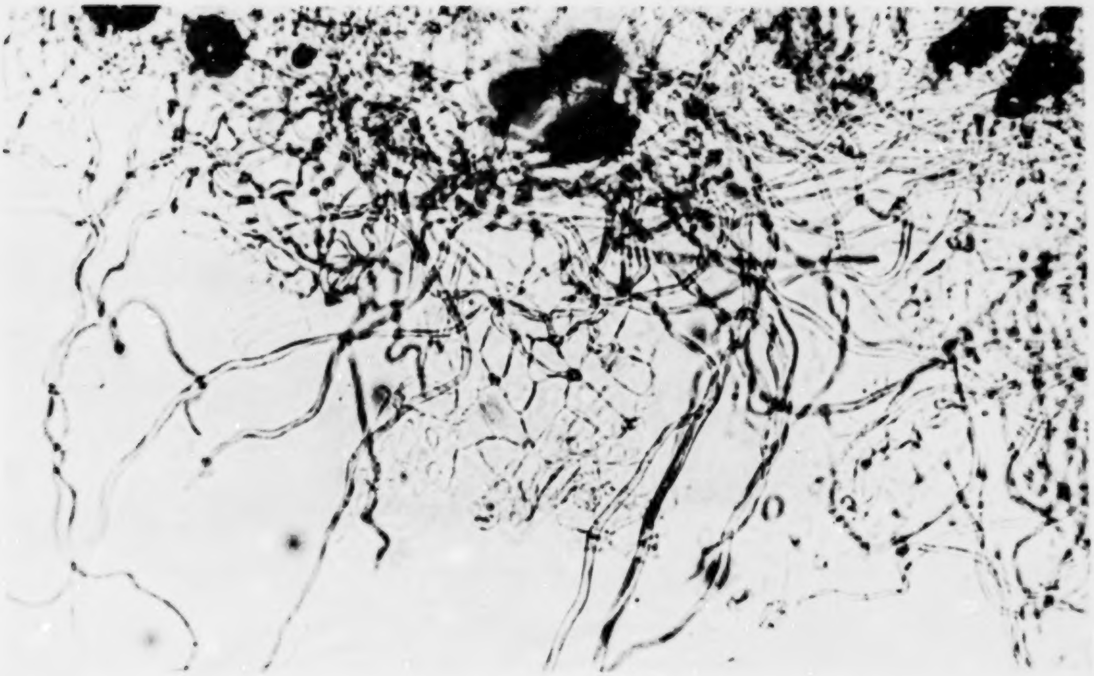
Eriogonum heracleoides (158)



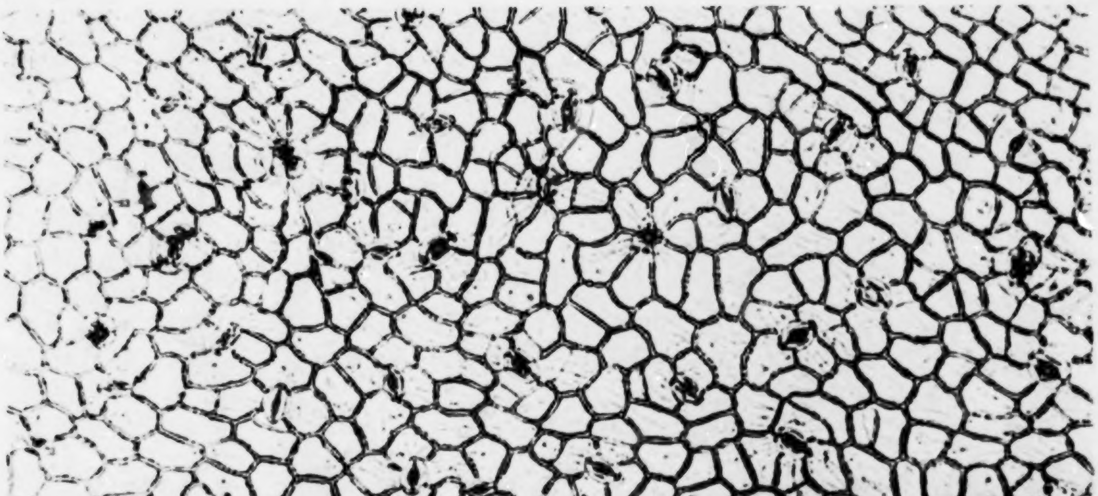
Eriogonum heracleoides (159)



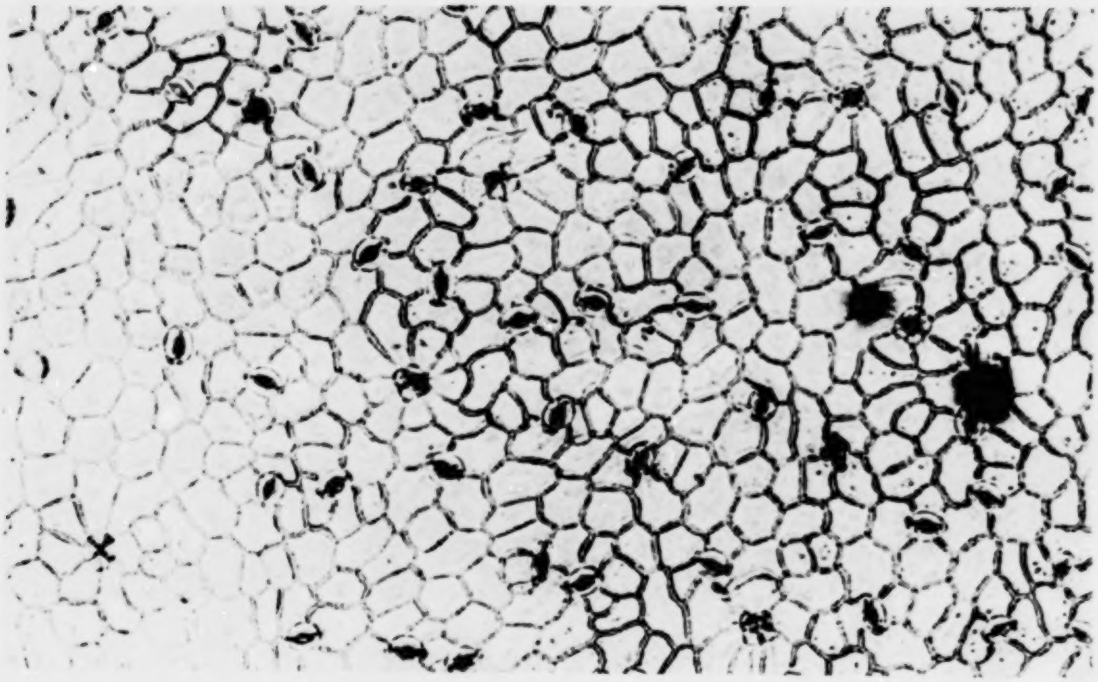
Eriogonum niveum (160)



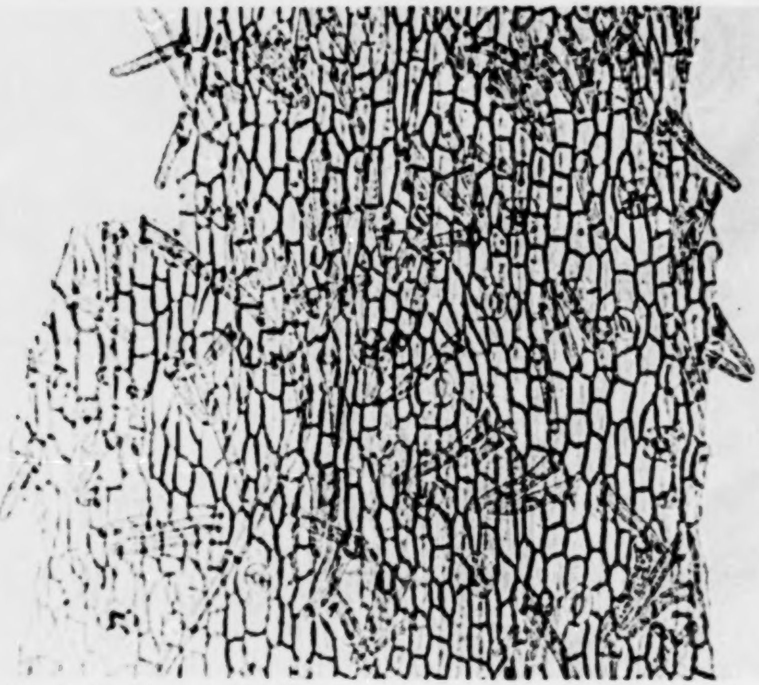
Eriogonum niveum (161)



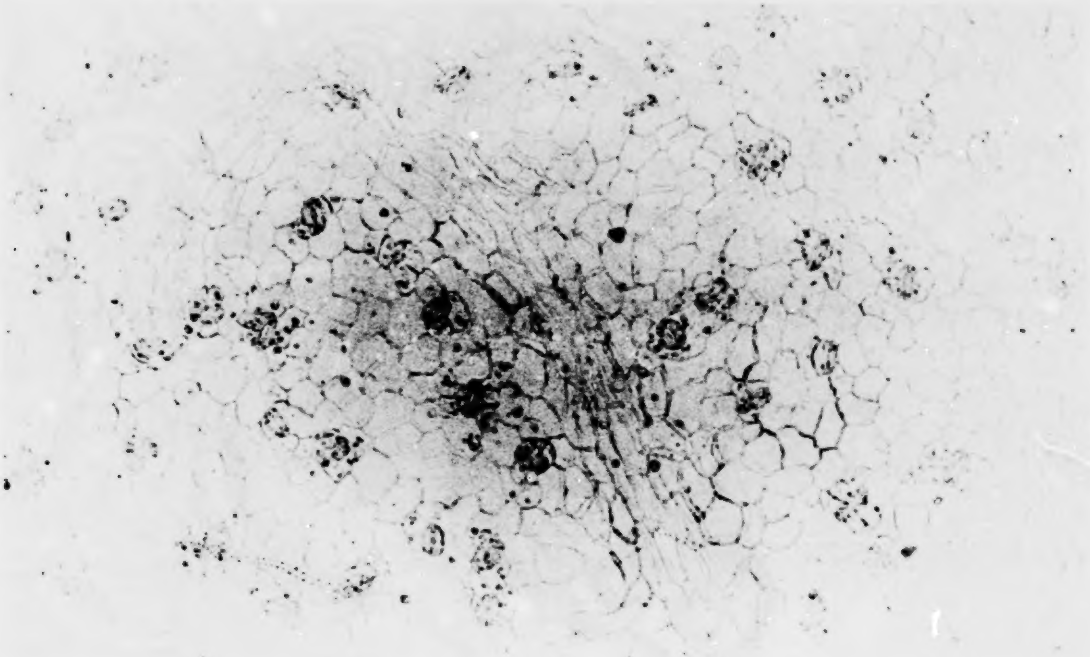
Penstemon fruiticosus (162)



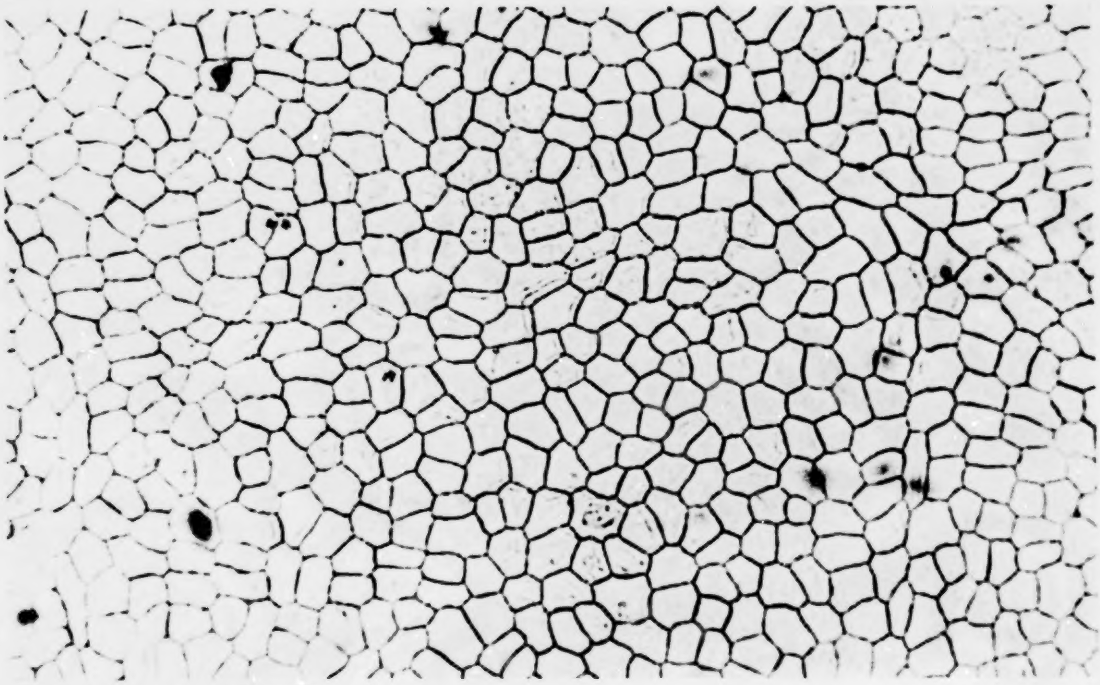
Penstemon fruiticosus (163)



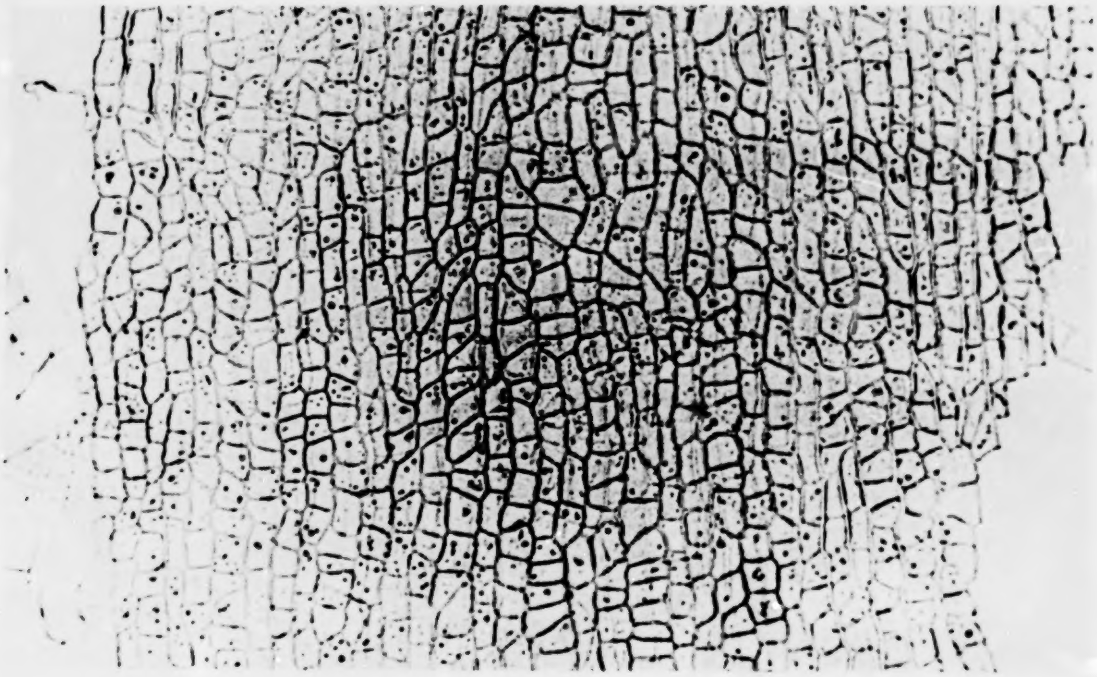
Penstemon fruiticosus (164)



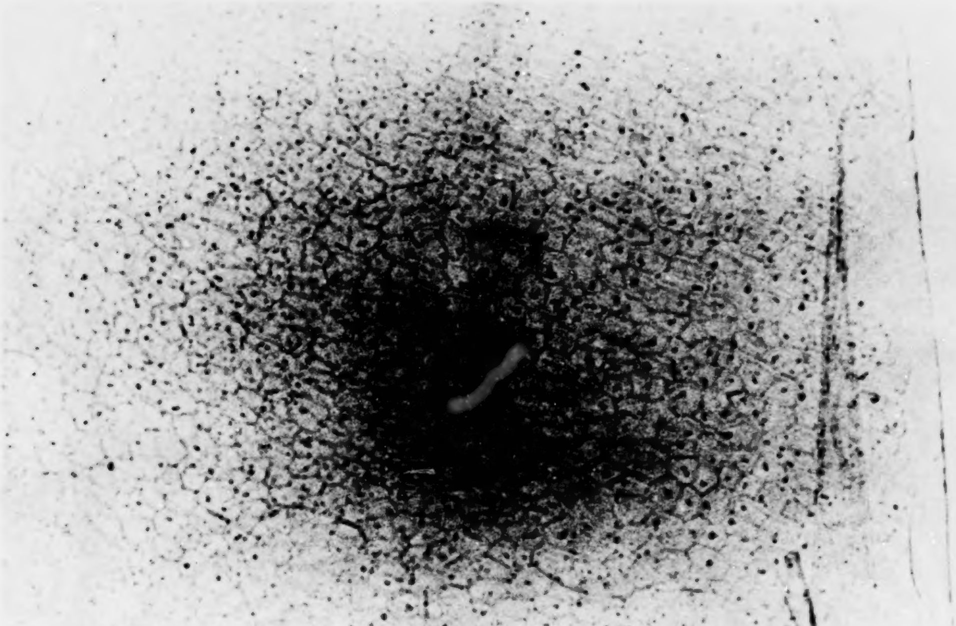
Philadelphus lewisii (165)



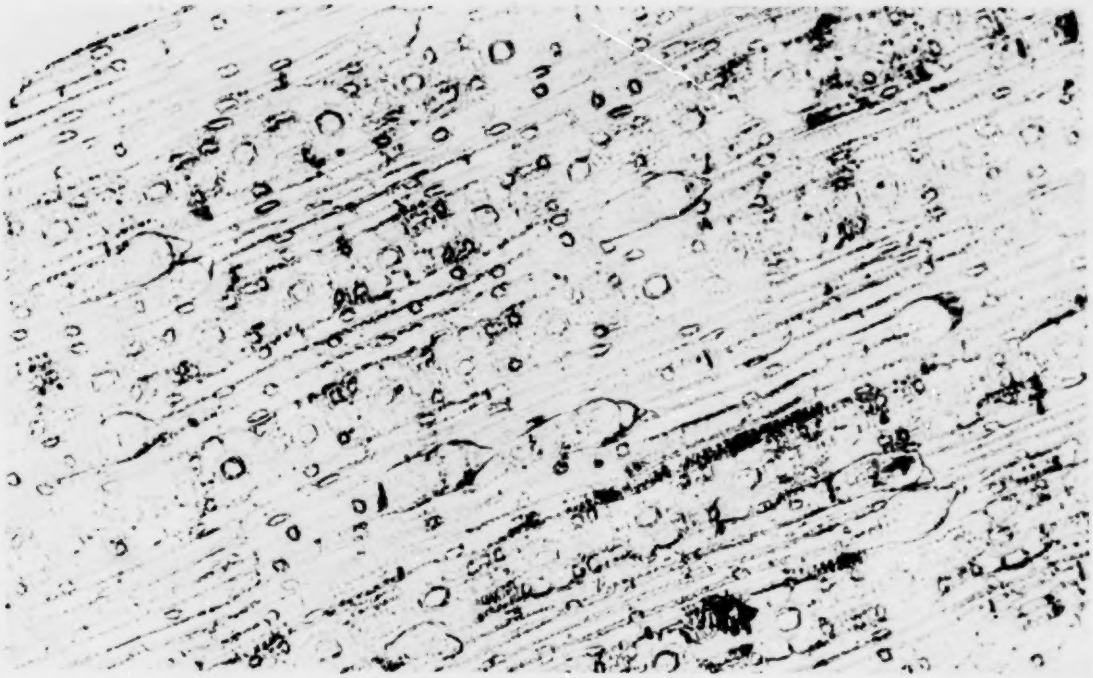
Philadelphus lewisii (166)



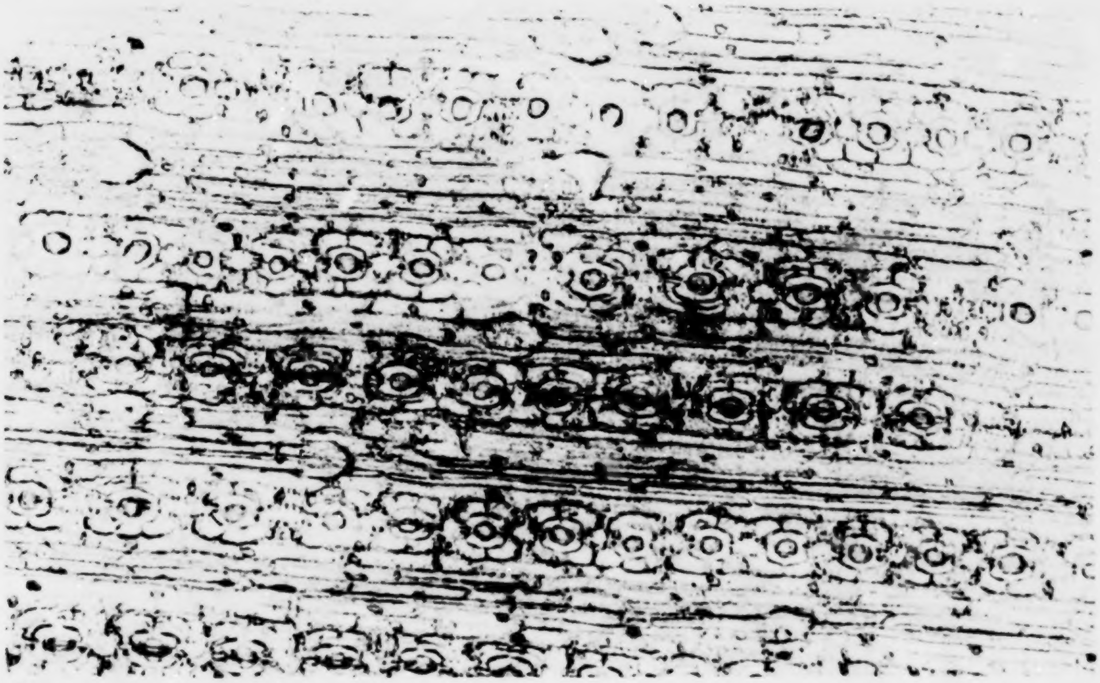
Philadelphus lewisii (167)



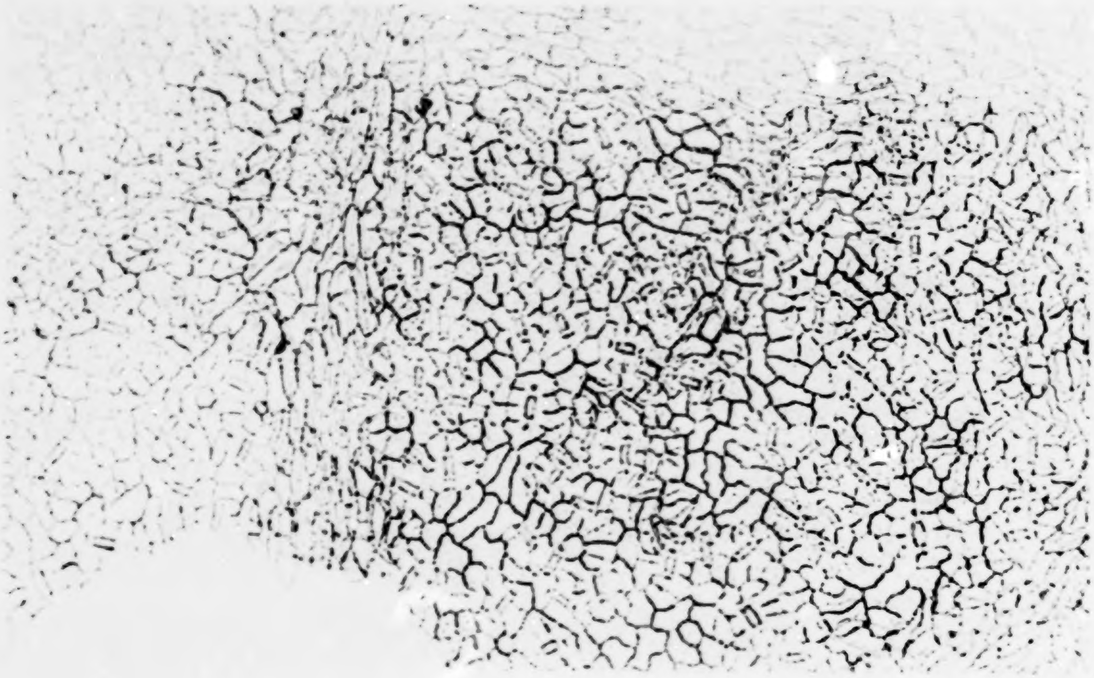
Philadelphus lewisii (168)



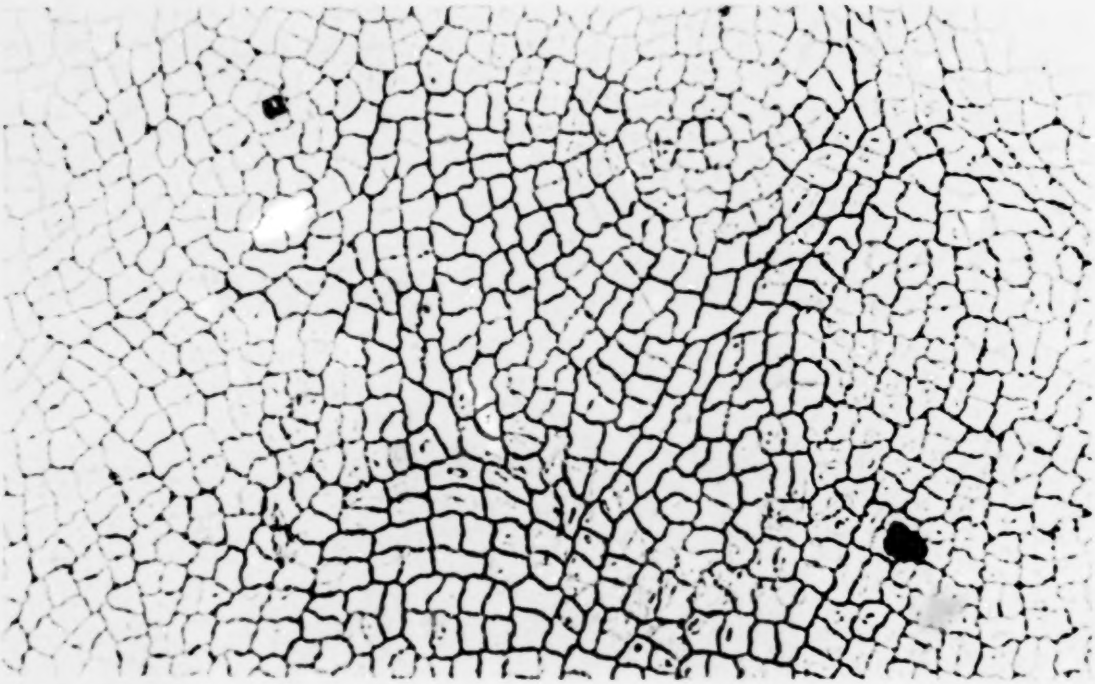
Pinus ponderosa (169)



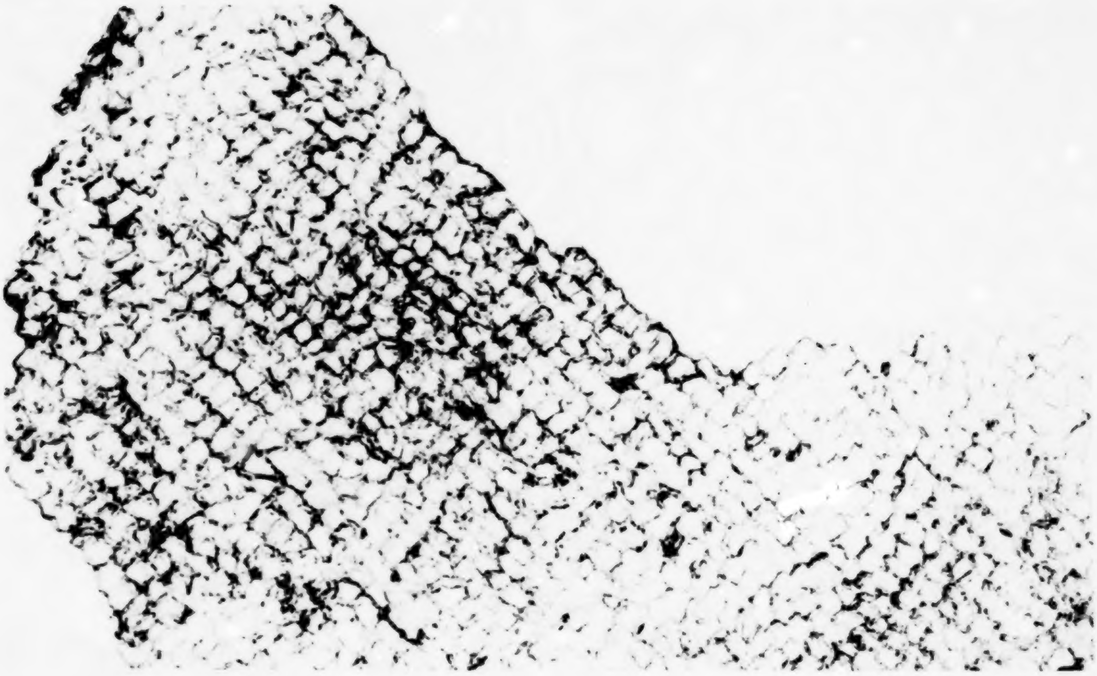
Pinus ponderosa (170)



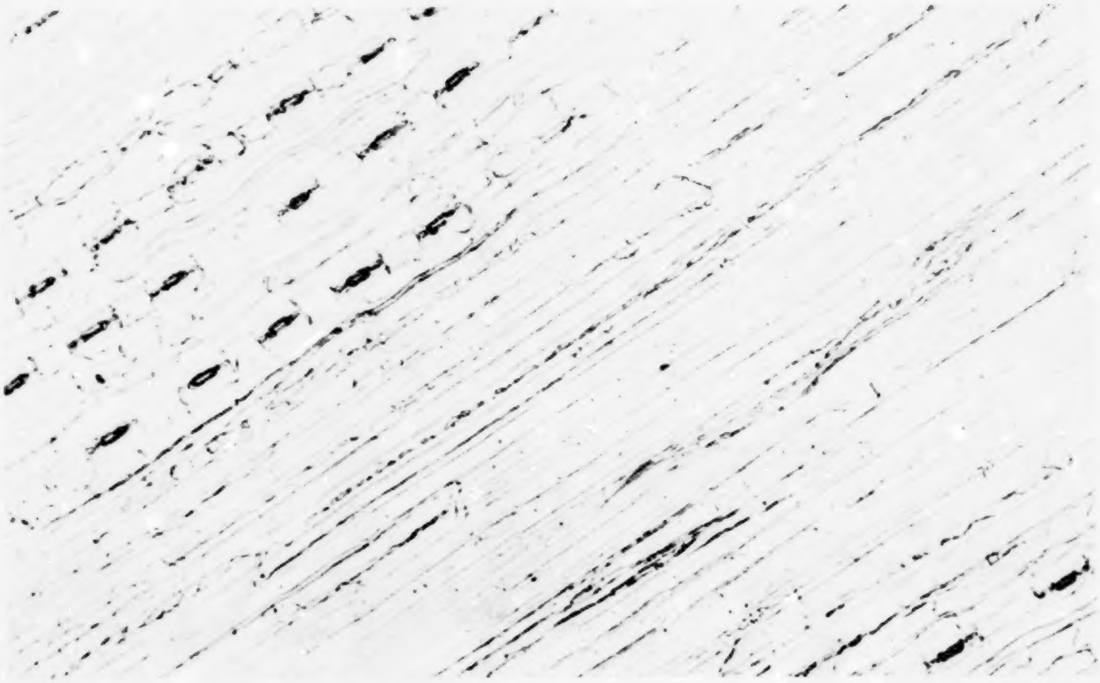
Prunus virginiana (171)



Prunus virginiana (172)

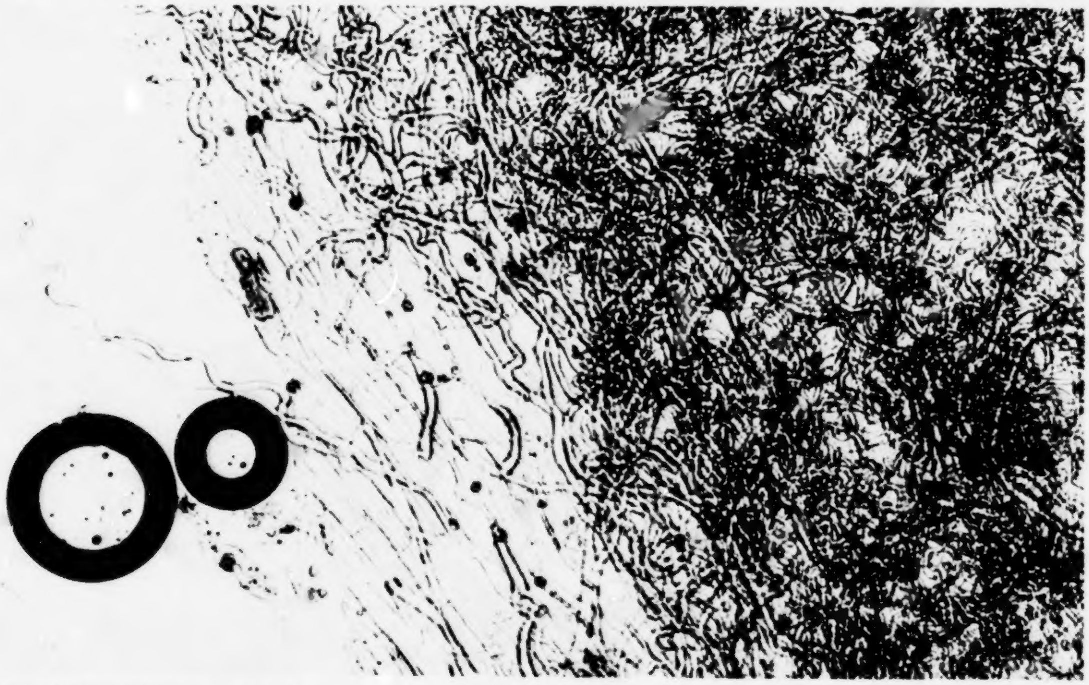


Prunus virginiana (173)

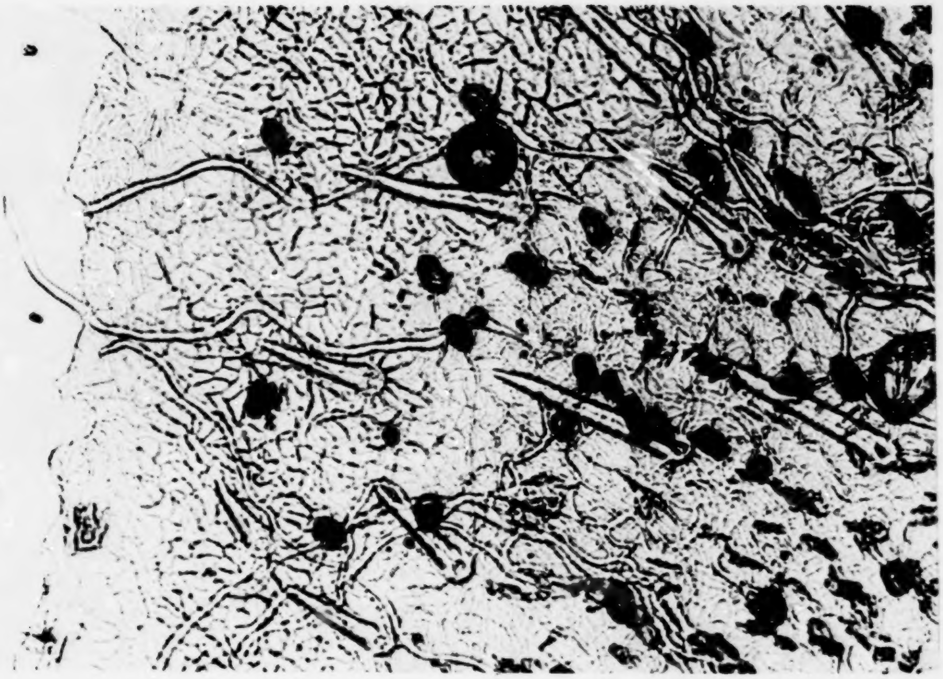


Pseudotsuga menziesii (174)

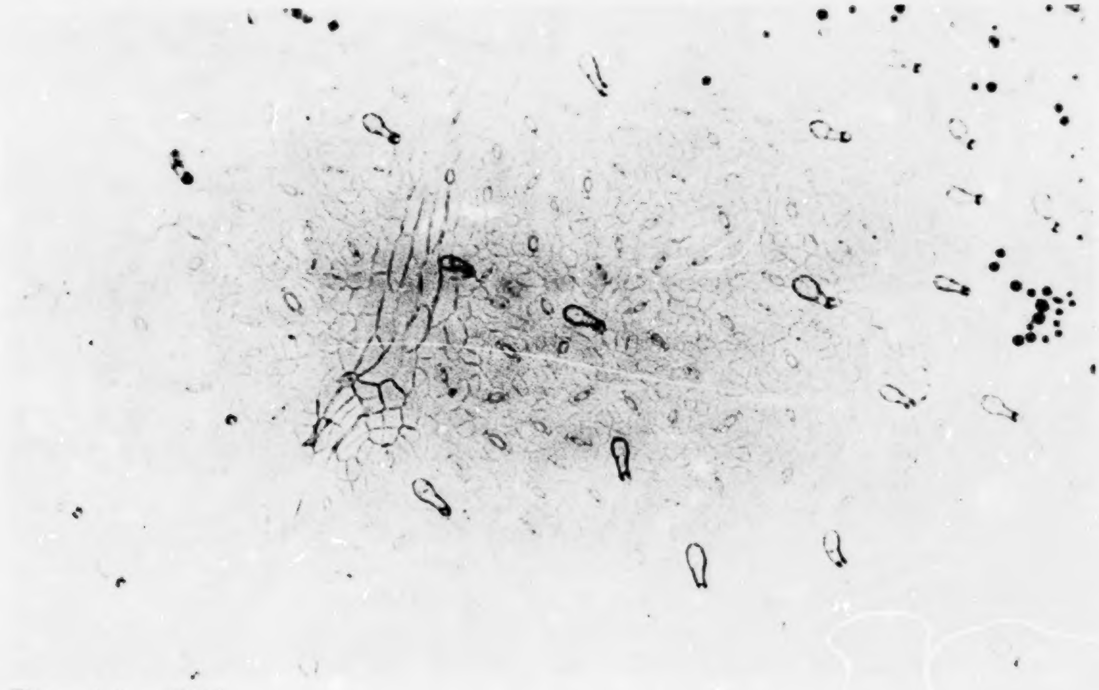
Pseudotsuga menziesii (175)



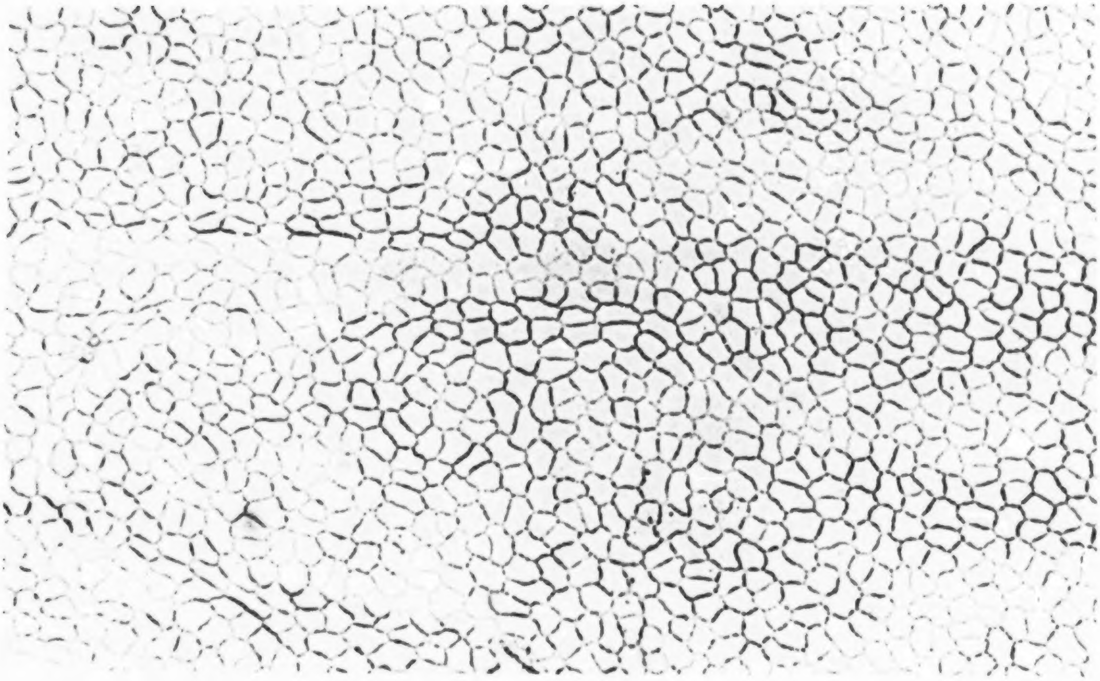
Purshia tridentata (176)



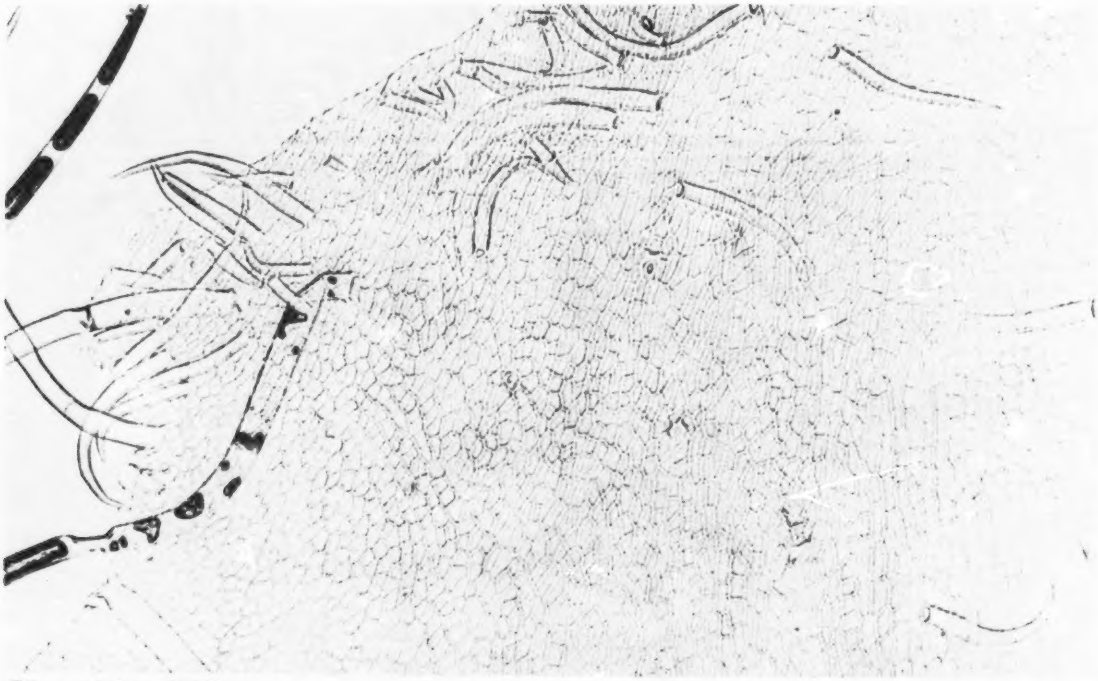
Purshia tridentata (177)



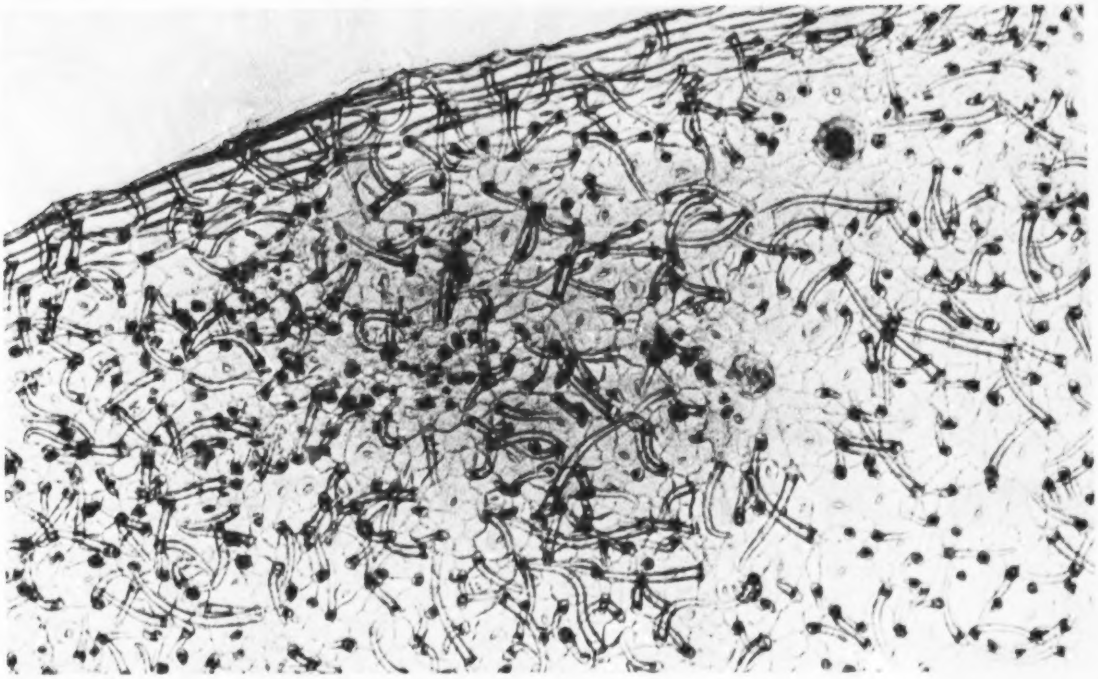
Rhus glabra (178)



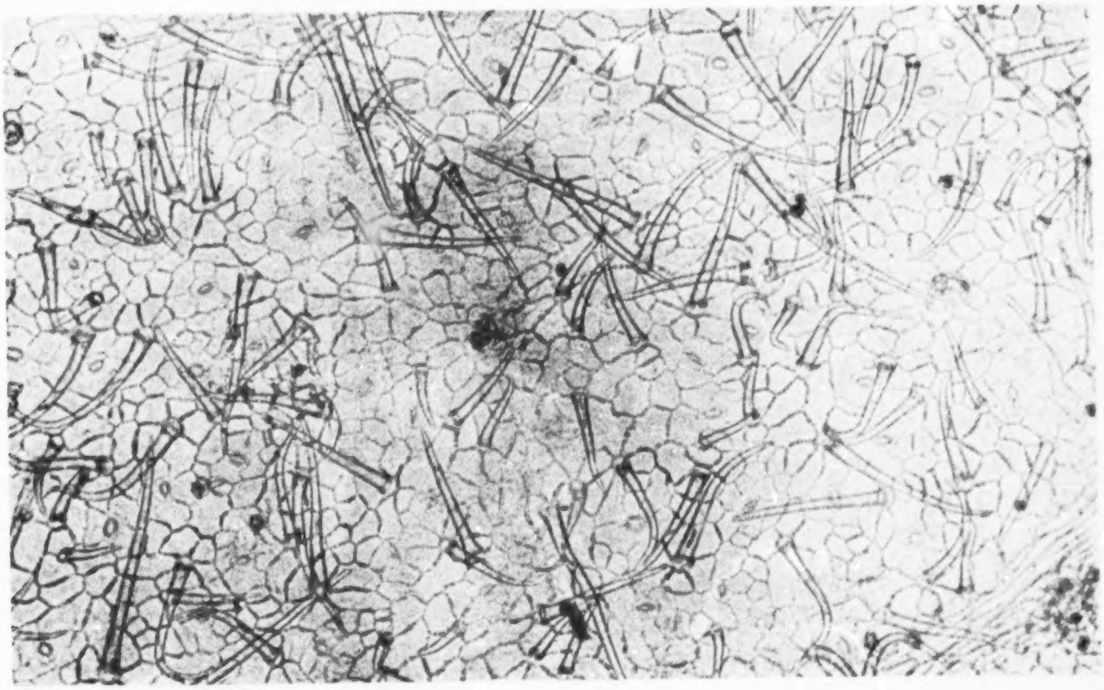
Rhus glabra (179)



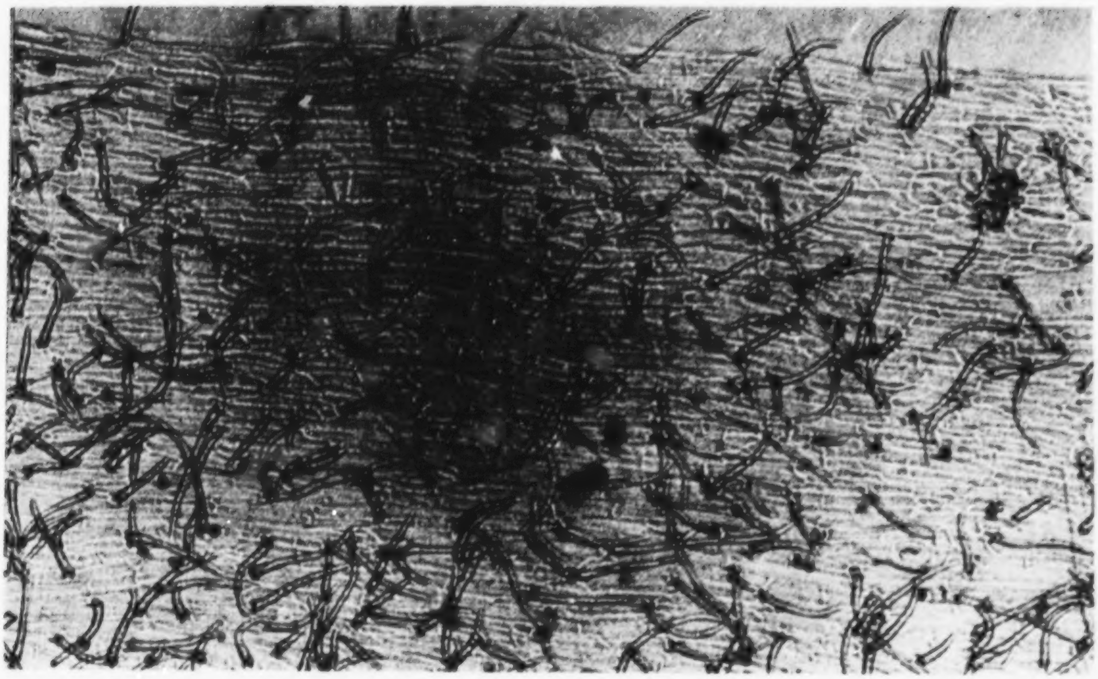
Rhus glabra (180)



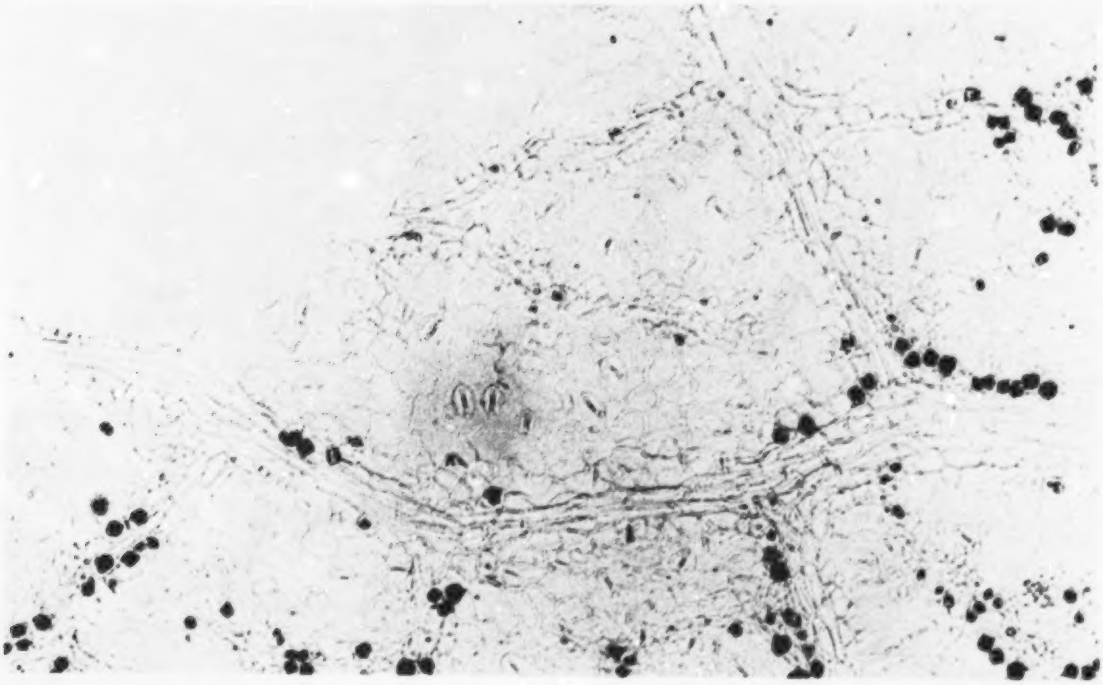
Ribes cereum (181)



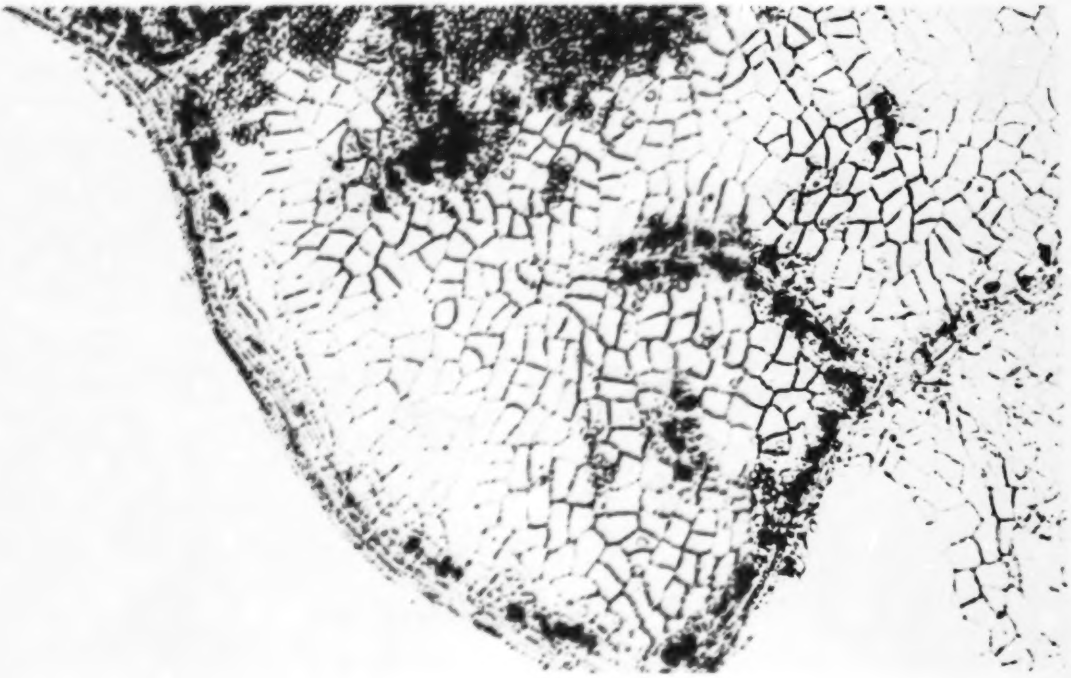
Ribes cereum (182)



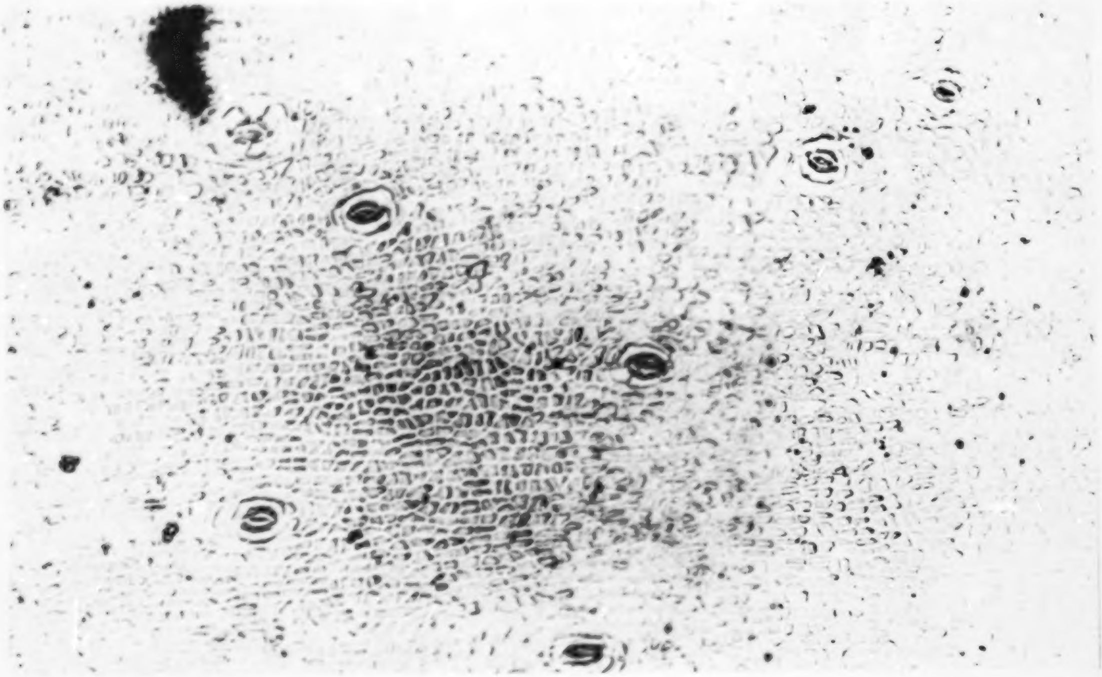
Ribes cereum (183)



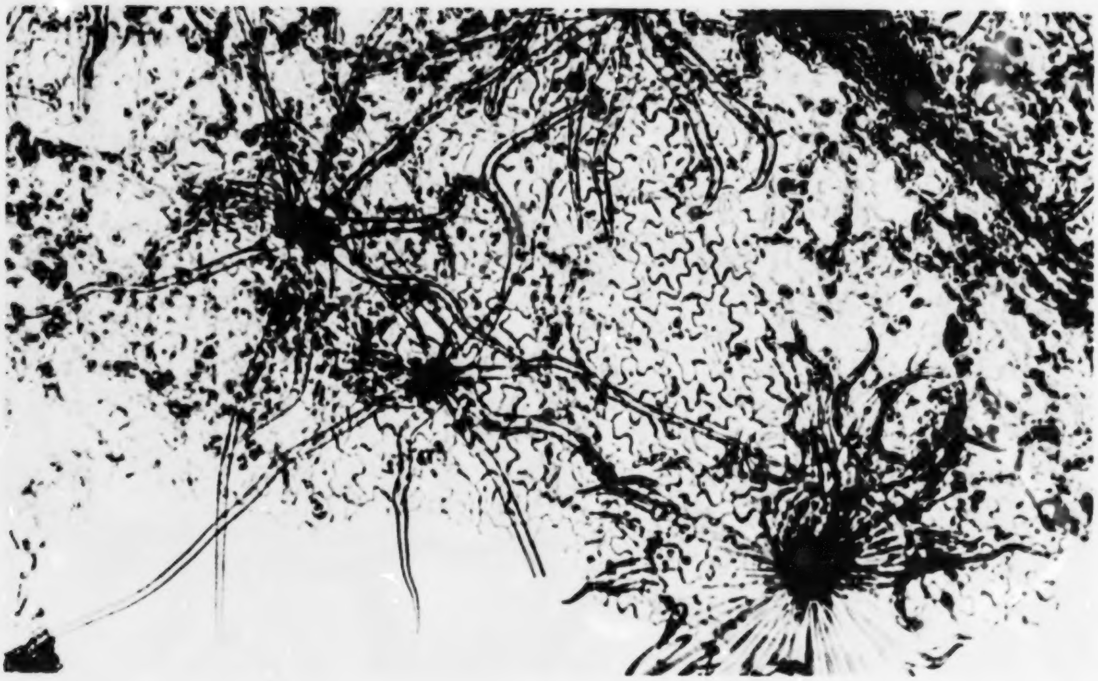
Rosa nutkana (184)



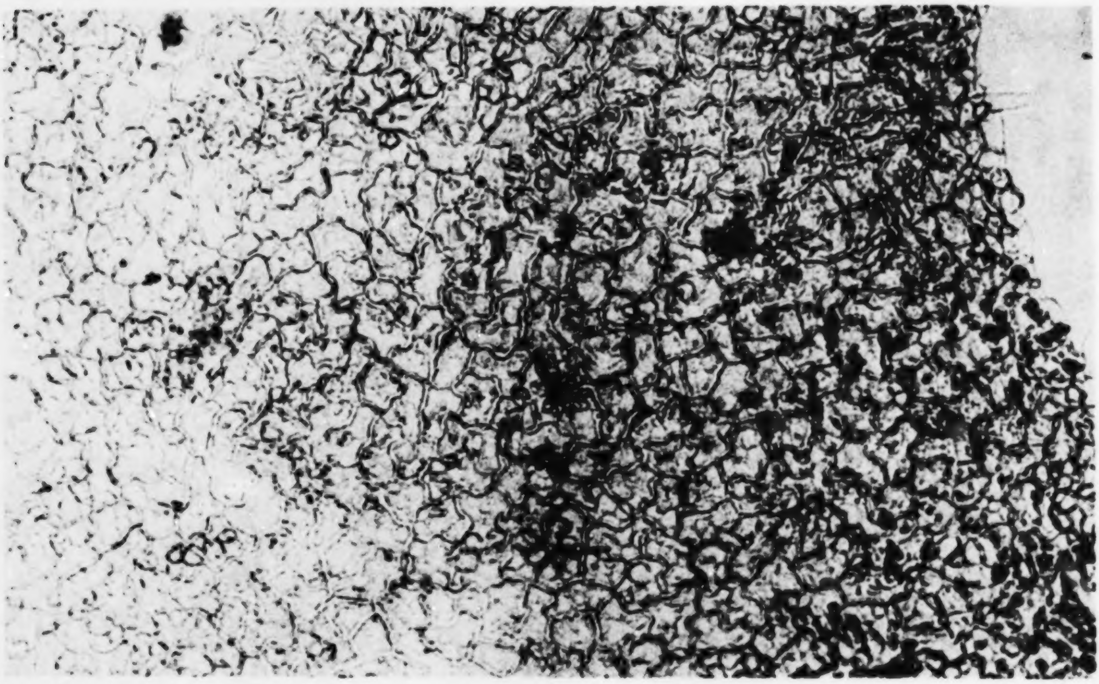
Rosa nutkana (185)



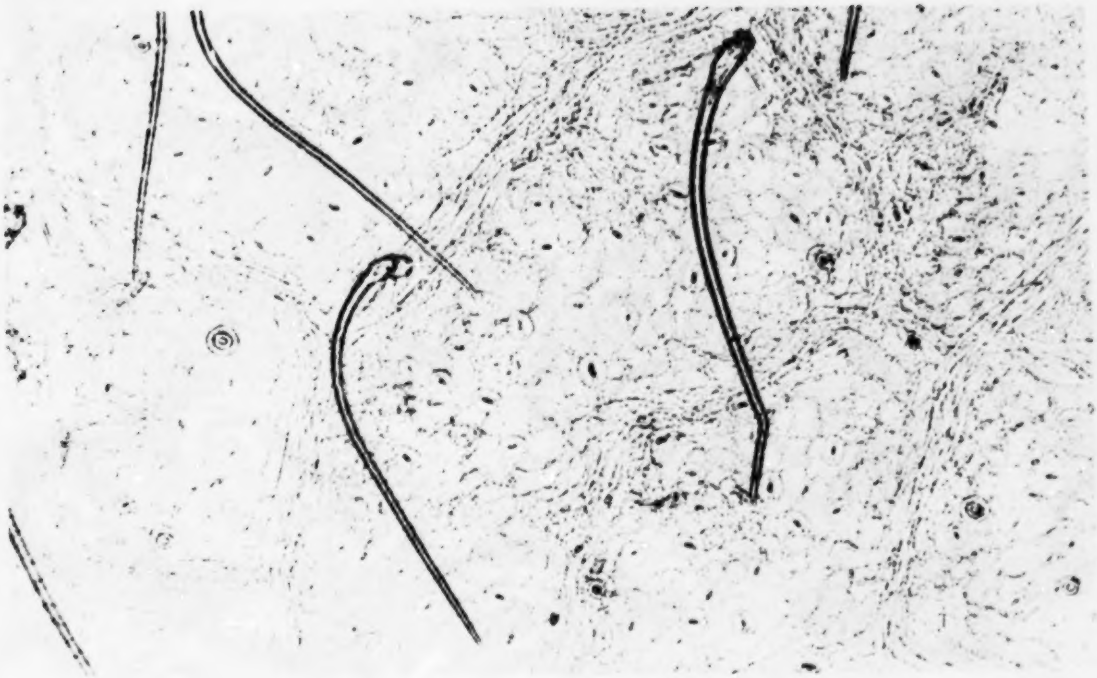
Rosa nutkana (186)



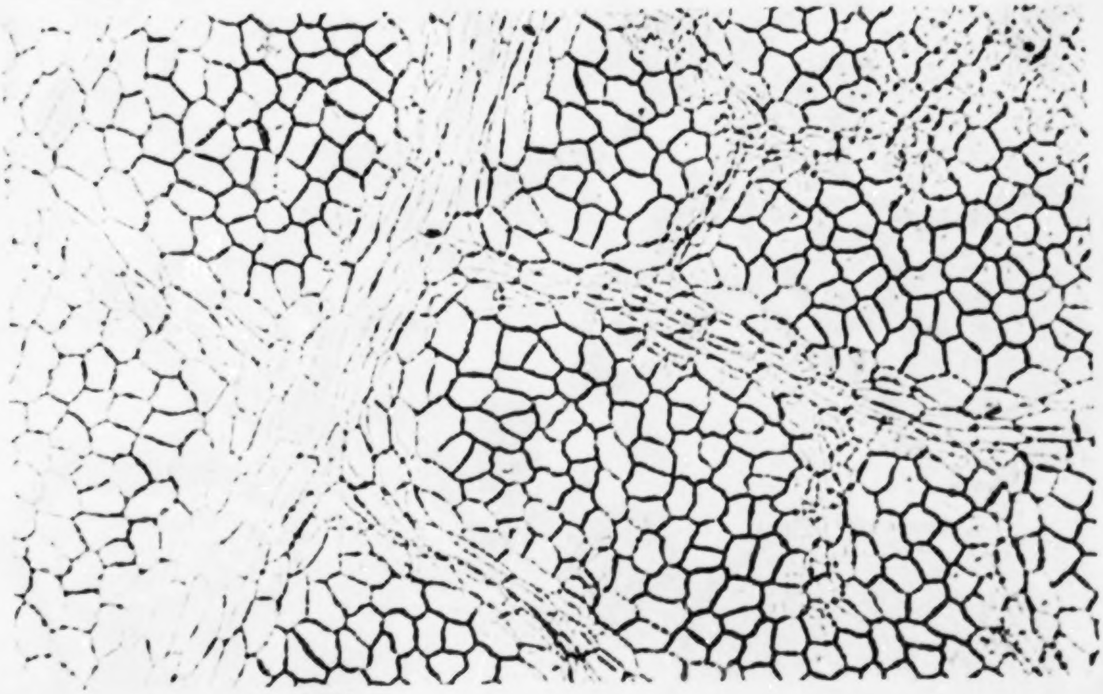
Shepherdia canadensis (187)



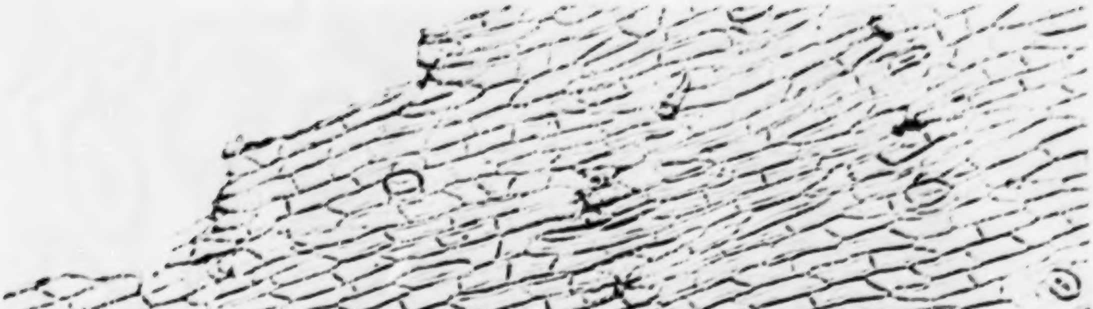
Shepherdia canadensis (188)



Symphoricarpos albus (189)



Symphoricarpos albus (190)



Symphoricarpos albus (191)

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APPENDIX I

Grasses and Sedges

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Agropyron spicatum	abaxial	1	10
	adaxial	2	10
	stem	3	11, 13
Apera interrupta	abaxial	4	12, 13
	adaxial	5	12
	stem	6	11
Bromus inermis	abaxial	7	9
	adaxial	8	8
Bromus mollis	abaxial	9	8
	adaxial	10	9
	stem	11	12
Bromus tectorum	abaxial	12	8
	adaxial	13	9
	stem	14	11
Carex petasata	adaxial	15	14
Dactylis glomerata	abaxial	16	9
	adaxial	17	9
Festuca idahoensis	abaxial	18	9
	adaxial	19	12
	stem	20	13
Festuca scabrella	abaxial	21	10
	adaxial	22	12
	stem	23	12
Koeleria cristata	abaxial	24	10, 13
	adaxial	25	8, 9
	stem	26	11
Poa pratensis	abaxial	27	10
	adaxial	28	8

Grasses and Sedges

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Poa sandbergii	abaxial	29	12
	adaxial	30	13
	stem	31	11
Stipa occidentalis	abaxial	32	9
	adaxial	33	10
	stem	34	13
Stipa comata	abaxial	35	10
	stem	36	13

APPENDIX II

Forbs

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Achillea millefolium	abaxial	37	16
	adaxial	38	16
	stem	39	21
Antennaria parvifolia	stem	40	17, 21
Arabis holboellii	abaxial	41	20, 32
	adaxial	42	31
	stem	43	20
Arnica sororia	abaxial	44	34
	adaxial	45	34
	stem	46	22
Astragalus miser	abaxial	47	33
	adaxial	48	32
	stem	49	20
Astragalus purshii	abaxial	50	30
	adaxial	51	30
	stem	52	19
Balsamorhiza sagittata	abaxial	53	30
	adaxial	54	36
	stem	55	22
	flower	56	23
Calochortus macrocarpus		57	14
Castilleja thompsonii	abaxial	58	34
	adaxial	59	34
	stem	60	22
Centaurea diffusa	abaxial	61	36, 38
	adaxial	62	23, 27, 36
	stem	63	18
Chaenactis douglasii	abaxial	64	20
	adaxial	65	34
	stem	66	20
Collinsia parviflora		67	29

Forbs

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Comandra umbellata	abaxial	68	34
	adaxial	69	34
Crepis atrabarba	abaxial	70	31
	adaxial	71	34
	stem	72	19
Delphinium bicolor		73	32
		74	31
Dodecatheon cusickii	abaxial	75	30
	adaxial	76	30
	stem	77	21
Epilobium angustifolium	abaxial	78	29
	adaxial	79	24, 31
Erigeron corymbosus	abaxial	80	33, 36
	adaxial	81	33, 36, 38
	stem	82	22
Erigeron filifolius	abaxial	83	20, 21
	adaxial	84	20
	stem	85	20
Erigeron pumilus	abaxial	86	30
	adaxial	87	30
	stem	88	21
Gaillardia aristata	abaxial	89	36
	adaxial	90	36
	stem	91	21
Geum triflorum	abaxial	92	33
	adaxial	93	33
	stem	94	18
Heuchera cylindrica	abaxial	95	26
	adaxial	96	26, 37
	stem	97	21, 37
Lewisia rediviva		98	25
		99	25
Lithospermum ruderale	abaxial	100	29
	adaxial	101	27
	stem	102	17

Forbs

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Lomatium triternatum	abaxial	103	37
	adaxial	104	37
	stem	105	19
Lupinus sericeus	abaxial	106	27
	adaxial	107	27
	stem	108	19
Medicago sativa		109	30
Microseris troximoides		110	18, 26
		111	26
Phacelia hastata	abaxial	112	27
	adaxial	113	27
	stem	114	18
Phlox longifolia	abaxial	115	16
	adaxial	116	16
	stem	117	16, 17
Plantago patagonica	abaxial	118	17, 22
	adaxial	119	17, 22
	stem	120	17, 22
Ranunculus glaberrimus		121	26, 29
Selaginella wallacei		122	15
Silene noctiflora	abaxial	123	29
	adaxial	124	33
	stem	125	17
Sisymbrium altissimum	abaxial	126	37
	adaxial	127	33
	stem	128	18
Smilacina racemosa	abaxial	129	30
	adaxial	130	15, 16
	stem	131	16
Tragopogon dubius	abaxial	132	34
	adaxial	133	34
	stem	134	23, 34
Zigadenus venenosus	abaxial	135	15, 16
	adaxial	136	15, 16
	stem	137	17

APPENDIX III

Trees and Shrubs

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Acer glabrum	abaxial	138	31
	adaxial	139	25
Amelanchier alnifolia	abaxial	140	32
	adaxial	141	24
	stem	142	24
Arctostaphylos uva-ursi		143	35
		144	25
Artemisia frigida	adaxial	145	19, 30
	stem	146	19
Artemisia tridentata	abaxial	147	33, 37
	adaxial	148	33, 37
	stem	149	33, 37
Berberis aquifolium	abaxial	150	31
	adaxial	151	29
	stem	152	16, 18
Ceanothus velutinus		153	25
Chrysothamnus nauseosus	abaxial	154	35
	adaxial	155	35
Cornus stolonifera	adaxial	156	23
Eriogonum heracleoides	abaxial	157	26
	adaxial	158	28
	stem	159	19
Eriogonum niveum	abaxial	160	26, 35
	adaxial	161	26, 35
Penstemon fruiticosus	abaxial	162	26
	adaxial	163	23
	stem	164	26

Trees and Shrubs

SPECIES	EPIDERMAL SURFACE	PHOTOMICROGRAPH NUMBER	PAGE NUMBER
Philadelphus lewisii	abaxial	165	35
	adaxial	166	24, 25
	stem	167	24
	flower	168	24
Pinus ponderosa	abaxial	169	14
	adaxial	170	14
Prunus virginiana	abaxial	171	35
	adaxial	172	24
	stem	173	24
Pseudotsuga menziesii	abaxial	174	14
	adaxial	175	14
Purshia tridentata	abaxial	176	17
	adaxial	177	25
Rhus glabra	abaxial	178	38
	adaxial	179	25
	stem	180	28
Ribes cereum	abaxial	181	37
	adaxial	182	37
	stem	183	19
Rosa nutkana	abaxial	184	35
	adaxial	185	27
	stem	186	27
Shepherdia canadensis	abaxial	187	29
	adaxial	188	29, 32
Symphoricarpos albus	abaxial	189	32
	adaxial	190	24
	stem	191	20

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No. R-2	Effects of selective logging on arboreal lichens used by Selkirk caribou. Susan K. Stevenson. November 1979. 75pp.
No. R-3	Seasonal movements of black-tailed deer on northern Vancouver Island. A.S. Harestad. December 1979. [illegible]pp.
No. R-4	A history of the pheasant in the Okanagan Region of southern British Columbia. D.J. Spalding and R.P. [illegible]. December 1981. [illegible]pp.
No. R-5	A manual for the identification by epidermal characteristics of 75 forage plant species of the southern interior of British Columbia. B.M. Wikeem and M.D. Pitt. May 1982. [illegible]pp.